U.S. ARMY
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— COMMITTED TO PROTECTION OF THE ENVIRONMENT —



# Air Remedial Investigation
# Final Report
## Volume I
## (Version 3.1)

August 1988
Contract Number DAAK11-84-D-0016
Task Number 18 (Air Monitoring)



**Environmental Science And Engineering, Inc.**

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LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Air Remedial Investigation
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PREPARED BY

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR ROCKY MOUNTAIN ARSENAL

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THE PURPOSES OF THE AIR MONITORING PROGRAM ARE TO DEFINE THE NATURE AND EXTENT OF AIRBORNE CONTAMINATION AND TO SUPPORT THE OTHER RI, EA, AND FS PROGRAMS. ONE YEAR OF BASELINE AIR QUALITY DATA WAS COLLECTED ON-POST TO USE IN COMPARING AIR QUALITY BEFORE, DURING, AND AFTER REMEDIATION. SITE-SPECIFIC AIR QUALITY INFORMATION WAS ALSO COMPILED TO USE IN PLANNING REMEDIAL ACTIONS.

SECTIONS OF THIS REPORT INCLUDE:

1. DESCRIPTION OF THE NATURE AND EXTENT OF THE PROBLEM
2. SUMMARY OF THE INVESTIGATION
3. ENVIRONMENTAL SETTING OF RMA
4. SAMPLING AND ANALYSIS PROGRAM
5. CONTAMINATION ASSESSMENT WITH CONCENTRATIONS OF CONTAMINANTS AND STANDARDS USED.

APPENDICES INCLUDE:

1. AIR QUALITY DATA


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# EXECUTIVE SUMMARY

The purpose of the air monitoring program at Rocky Mountain Arsenal (RMA) was to define the nature and extent of airborne contamination, and to support the other Remedial Investigations (RI), Endangerment Assessments (EA), and Feasibility Studies (FS) at RMA. One year of onpost baseline air quality data was collected. Site-specific data was compiled for use in planning remedial actions.

This report presents a brief description of the sampling and analysis program including references to the Task 18 Technical Plan, and documentation of field modifications to that plan. The majority of this report is dedicated to the assessment of the airborne contaminants that were monitored at RMA from spring 1986 to fall 1987. The pollutants that were monitored included total suspended particulates (TSP), particulates less than 10 microns in size (PM-10), asbestos, volatile and semivolatile organic compounds, and metals.

In general, there are no significant sources of airborne contaminants at RMA. Particulate levels are below Federal guidelines for annual average concentrations of TSP and PM-10 onpost at RMA. Asbestos was non-detectable in all airborne samples. Volatile organics, semivolatile organics, and metals were collected during event sampling near source areas such as Basin A and Basin F. The levels that were detected were comparable to levels detected in previous investigations. The EA will evaluate the significance of the airborne organics and metals.

In addition to collection of air quality data, Task 18 activities included evaluation of climatological and meteorological data collected at onpost meteorological stations. Supplemented by nearby, long-term data collected at Stapleteon International Airport, the general atmospheric tendancies at RMA were defined. As is common to the rest of the Denver metropolitan area, early morning inversions are usual. Nearly 60 percent of the year, Denver experiences stable atmospheric conditions which favor air pollution events. The majority of stable conditions are observed during the winter.

# 1.0 INTRODUCTION

The original purpose of the air monitoring program at Rocky Mountain Arsenal (RMA) was to define the nature and extent of airborne contamination, and to support the other Remedial Investigations (RI), Endangerment sessments (EA), and Feasibility Studies (FS) at RMA. One year of baseline air quality data was collected onpost for use in comparison of air quality before, during, and after remedial actions. Site-specific air quality information was also compiled for use in planning remedial actions.

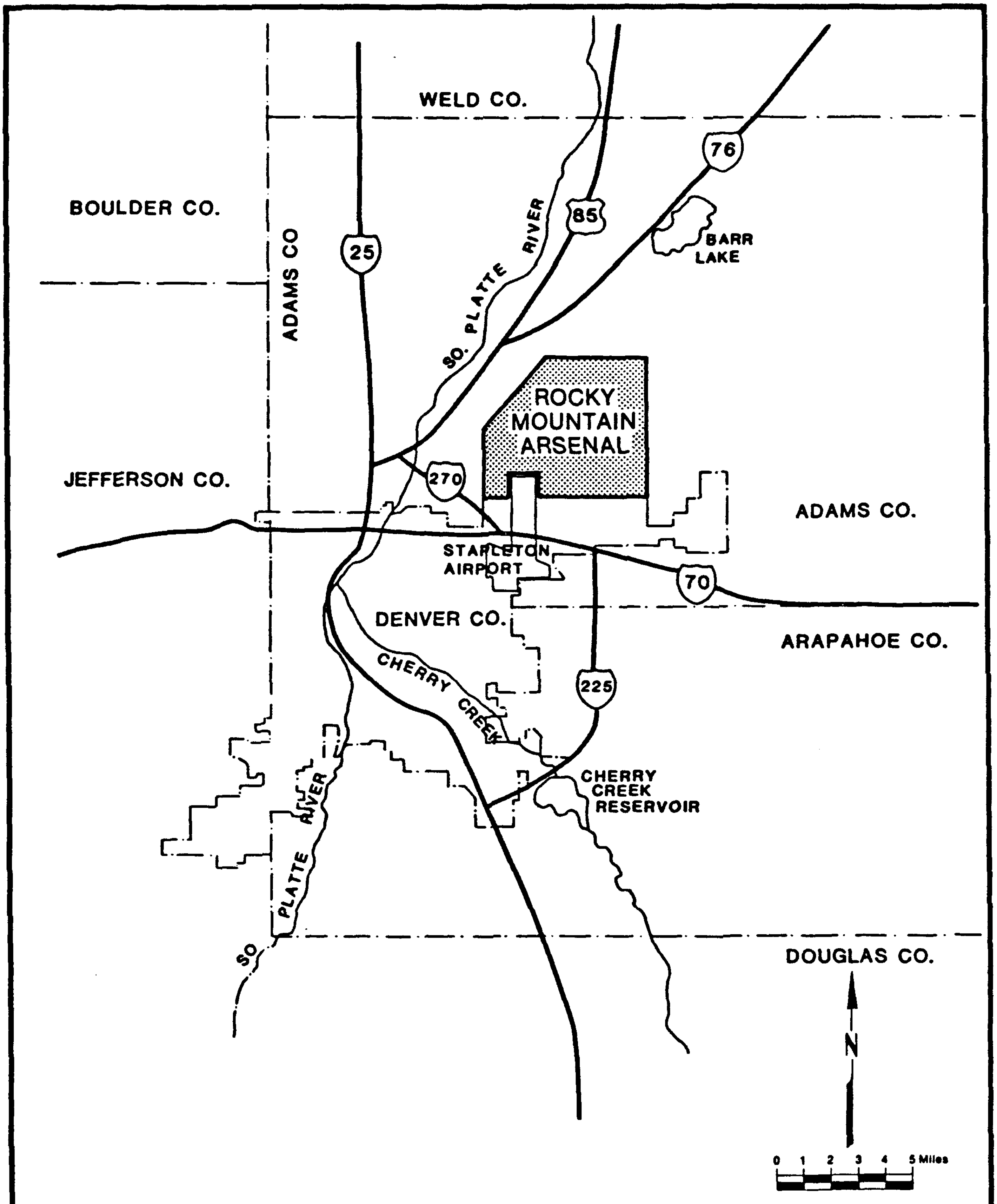
This section contains information about RMA, a description of the nature and extent of the problem, a summary of the investigation, and an overview of the report. The remainder of the report describes the Environmental Setting (Section 2.0); the Sampling and Analyses Program (Section 3.0); the Nature and Extent of Contamination (Section 4.0); and, the Contamination sessment (Section 5.0).

## 1.1 SITE BACKGROUND INFORMATION

RMA occupies over 17,000 acres (27 square miles) northeast of Denver, Colorado in western Adams County (Figure 1.1-1). RMA was established in 1942 and was used for the manufacture of chemical and incendiary munitions as well as for the demilitarization of chemical munitions. Industrial chemicals were manufactured at RMA from 1947 to 1982.

During the period from 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company (Hyman). CFI manufactured chlorinated benzene and dichlorodiphenyltrichloroethane (DDT), while Hyman produced a variety of pesticides, insecticides, and herbicides. In 1949, the CFI lease was terminated, and the property which had been under lease to CFI was leased to Hyman. In 1951, Shell Chemical Company (Shell) assumed the Hyman




| Figure 1.1-1<br>LOCATION MAP OF<br>ROCKY MOUNTAIN ARSENAL<br>SOURCE: ESE, 1988 | **Prepared for:**<br>**U.S. Army Program Manager's Office**<br>**For Rocky Mountain Arsenal**<br>**Aberdeen Proving Ground, Maryland** |
|---|---|

lease. Shell ceased manufacturing in 1982 and its lease expired in 1987. Construction of facilities for the production of Sarin (GB) nerve agent began in 1950 and was completed in 1953. Manufacture of GB was continued until 1957 and GB munitions filling operations continued until late 1969.

Basin A, located in a natural depression within Section 36, was the original disposal area for waters and waste waters resulting from all RMA and industrial operations (Figure 1.1-2). In 1952, the impoundment dike was raised 5 feet (ft) to handle additional waste generated by the GB plant. During the period from 1943 to 1956, Basin A was the primary receptor of liquid waste. Overflows went through the open drainage to Basin B, a natural low area, Basin C, constructed in 1953, and Basins D and E, which were constructed in 1943. Basin F was constructed in 1956 to contain all waste waters from the basins. Transfer of liquids to Basin F was completed by 1958.

During the period from 1965 to 1969, demilitarization of phosgene and cyanogen chloride munitions was performed at RMA. Disposal of mustard munitions occurred when 582,363 gallons (gal) were demilitarized as of February 1974. Demilitarization of 21,114 GB munitions was performed from 1973 to 1976 (Melito and Moloney, 1978, RIC#83235R02).

Disposal practices at RMA have included routine discharge of industrial waste effluent to unlined evaporation basins and burial of solid wastes at various locations. In general, these disposal practices were poorly documented. Unintentional spills of raw materials, process intermediates, and final products have occurred within the manufacturing complexes at RMA. Many of these compounds are mobile in surface and ground waters as well as in air.

## 1.2 NATURE AND EXTENT OF THE PROBLEM

### 1.2.1 CONTAMINANT SOURCES

Potential sources of airborne contaminants within the boundaries of RMA have been identified and are shown in Figure 1.1-2. Previous air monitoring studies conducted at RMA and current remedial investigations indicate that potential sources of airborne emissions exist from the South Plants area,

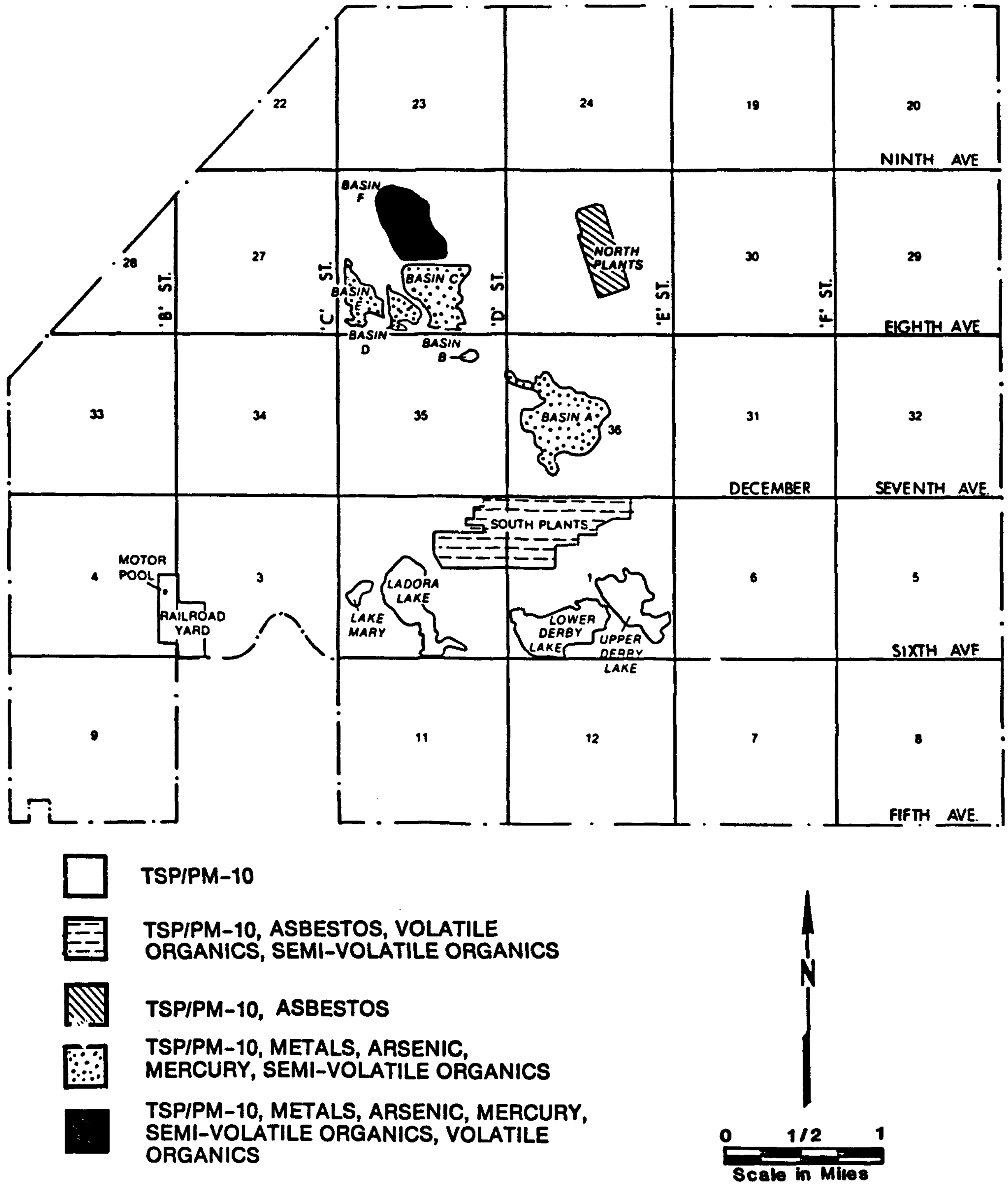



Figure 1.1-2
RMA SITE PLAN AND MAJOR SUSPECTED CONTAMINANT SOURCE AREAS
SOURCE: ESE, 1988

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through Sections 36 and 26, to Basin F. Because production and demilitarization activities have ceased, there are no longer discrete or point sources of emissions at RMA. Rather, the sources shown in Figure 1.1-2 are large areas of fugitive sources whose emissions are a function of atmospheric conditions, surface cover, and the physical state of the contaminants.

Based upon historical records of disposal activities and chemical spills, the following general areas are suspected of being the major sources of fugitive airborne emissions at RMA:

- South Plants - Volatile and semivolatile organic compounds (VOC and SVOC), and asbestos;
- Basin A - SVOCs, metals, and particulates; and
- Basin F - VOCs, SVOCs, metals, and particulates.

There are other minor sources suspected of contributing to airborne levels of the contaminants listed above. The following sections describe both major and minor sources.

#### 1.2.1.1 South Plants

The South Plants area was used by CFI, Hyman, Shell, and the U.S. Army from the early 1940's to the early 1980's for chemical production. These chemicals included pesticides, herbicides, insecticides, and chemical warfare agents. Although production has ceased at the South Plants' facilities, contaminants have been observed in ground water near the South Plants and, under certain conditions, airborne organic contaminants are odiferous. There are, however, no open basins of waste in the South Plants. Surface soils which contain contaminated materials in the South Plants may contribute to airborne pollution during dry, windy conditions.

In addition to being a potential source of VOC and SVOC emissions, the South Plants may also be a source of asbestos contamination. The facilities in the South Plants were constructed at the time when the use of asbestos

insulation was common practice. With the deterioration of the buildings in the South Plants, asbestos fibers may be released from these buildings.

1.2.1.2 Basin A

Basin A is located in Section 36 and was the original disposal area for all of the waste from the South Plants activities. When the North Plants came on-line, wastes from that operation were also disposed in Basin A. The approximate maximum areal extent of Basin A is shown in Figure 1.1-2.

When construction of Basin F was completed in the mid-1950's, all discharge of waste to Basin A was stopped. Currently, the basin is relatively dry with some ponding in the wetter months of the year, mainly in the summer after heavy rains. During the winter months, the basin becomes dry and dusty. Strong winds which prevail in the spring can create dust clouds from Basin A because of the lack of a vegetative cover. Currently, dust pallatives are being applied to the dry, exposed areas of Basin A. No odors have been noted that can be directly attributed to Basin A.

A wide variety of organics, including pesticides and agents, were introduced to Basin A since 1943. Inorganic metals as well as inorganic non-metals are also present. The near-surface soil contamination is well documented in the Contamination sessment Reports (CAR) for Section 36. Metals concentrations have been noted in near-surface soils with the most prevalent metals being arsenic and mercury. Concentrations for these metals have been noted as high as 1,100 parts per million (ppm) for arsenic and 65 ppm for mercury, but, in general, concentrations averaged less than 20 ppm for arsenic and 0.2 ppm for mercury.

The other near-surface soil contaminants that has been observed in Basin A are the organochlorine pesticides, such as aldrin, dieldrin, and endrin. Maximum concentrations were realized as high as 700 ppm with average concentrations at approximately 10 ppm.

1.2.1.3 Basin F

Basin F is a 93-acre, asphalt-lined surface impoundment in Section 26 with a holding capacity of 245,090,000 gal. The basin was constructed in 1956 to

hold the industrial wastes and wastewaters generated on RMA. A 12-inch layer of soil was placed over the 3/8-inch thick asphalt liner to protect it from erosion and degradation due to sunlight.

All aqueous waste discharge activities into Basin F ceased in December 1981. Field reconnaissance conducted in June 1985 indicated the existence of two separate pools of liquid in Basin F covering approximately 40 to 50 percent of the basin bottom for an estimated total liquid volume of 3 to 4 million gal. A noticeable odor emanates from the basin. This odor is strongest during the warmer periods of the year, although odors are noticeable during cold months. The portions not covered by liquid are soft and wet. Dust emissions from the basin have not been noted.

The disposal history of Basin F has been well documented and, therefore, the types of contaminants that can be expected are similarly documented. Numerous studies have been conducted to characterize Basin F fluids. The results of a 1978 study (Asselin and Hildebrandt, 1978, RIC#81324R09) indicate that contaminants contained in Basin F fluids include but are not limited to:

| | |
|---|---|
| Alcohols | p-Chlorophenylmethyl sulfide (CPMS) |
| Chloride | p-Chlorophenylmethyl sulfoxide (CPMSO) |
| Chlorinated Organics | p,p-Dichlorodiphenyldichloroethylene (DDE) |
| DDT | Pesticides |
| Dicyclopentadine (DCPD) | Phenols |
| Diisopropylmethyl phosphonate | Phosphorous |
| Fluoride | Sulfate |
| Insecticides | Sulfone. |
| Metals | |

The results of these studies also indicated that the liquids in Basin F are relatively homogeneous.

A study performed by the U.S. Army Engineer Waterways Experiment Station (WES) evaluated the contaminant distribution in Basin F (Meyers and Thompson, 1982, RIC#82350R01). The study included development of sampling protocols for Basin F materials, leach testing, and chemical analysis of

numerous soil cores from the borings constructed below the [illegible]
The results of this study indicate the presence of [illegible]
contaminants in soils:

| | |
|---|---|
| Acetophenone | Endrin |
| Aldrin | Fluoride |
| Arsenic | Isodrin |
| p-Chlorophenylmethylsulfone ($CPMSO_2$) | Mercury |
| CPMSO | Metals |
| Dibromochloropropane (DBCP) | Pentachloroethane |
| Dieldrin | Tetrachloroethylene |
| Dimethylmethylphosphonate (DMMP) | Tol[illegible] |
| DIMP | Tri[illegible] |
| Dithiane | Xyl[illegible] |

### 1.2.1.4 Other Contaminant Source Areas

In addition to the South Plants and Basins A and F, there are several other areas within RMA which could potentially contribute to airborne contaminants. Within Section 36 there is historical evidence of pesticide pits, munitions testing areas, burn sites, settling p[illegible] [illegible]ches. These areas are dry and may be a source of SVOCs, metals, and other particulates. Between Section 36 and Basin F are Sections 26 and 35 in which Basins B, C, D, and E are located. These basins are currently dry although at one time liquids from Basin A flowed into them. Because of this, the suspected contaminants in Basins B, C, D, and E would be similar to those found in Basin A. No odors have been noted from these basins, however, particulates may become airborne during high wind events.

Sections 3, 4, 5, 6, 11, 12, 19, 20, 27, 29, 30, 31, [illegible] and [illegible] of RMA contain some or all of the following: munitions impact [illegible], burn sites, disposal pits, spill areas, and trenches. Contaminants from these source areas may include VOCs, pesticides, herbicides, and heavy metals. No odors have been directly attributed to any of these sources.

## 1.3 SUMMARY OF PREVIOUS INVESTIGATIONS

Observations of airborne contaminants have been documented by various agencies and personnel at RMA since the 1960's. Studies have been undertaken as response actions to RMA operations, as well as to establish

background levels of ambient contaminants at RMA. The data indicate that some emissions had resulted from specific operations and that the contaminants are no longer being emitted to the atmosphere since operations ceased. Examination of ambient air data also indicates that dust and vapor emissions from known fugitive sources within RMA contained contaminants specific to the source.

The U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six contaminants referred to as "criteria pollutants". The six pollutants include total suspended particulates (TSP), lead, sulfur oxides, nitrogen oxides, ozone, and carbon monoxide (CO). All of these pollutants have been monitored in the vicinity of RMA by Federal and State agencies, but only a few were monitored within the boundaries of RMA. Regional air quality of criteria pollutants is contained in annual reports published by the State of Colorado (CDH, 1987).

The U.S. Army Environmental Hygiene Agency (USAEHA) has been the primary agency responsible for monitoring airborne contaminants at RMA. In addition to monitoring standard criteria pollutants, USAEHA monitored toxic contaminants including organics and metals. Table 1.3-1 summarizes air quality sampling programs at RMA.

A sample of the blowing dust was obtained from the southern part of Basin A during a wind storm in September 1977 (Witt, 1978). The chemical analysis of this sample detected a number of contaminants including:

| | |
|---|---|
| Aldrin | Dieldrin |
| Arsenic | Dithiane |
| CPMS | Endrin |
| CPMSO | Mercury |
| $CPMSO_2$ | Isodrin. |
| Copper | |

The Environmental Division Contamination Migration Branch sampled air near Basin F in November 1980 (Engineering Laboratory, 1980). This sample contained dimethyl acetamide, DMMP, toluene, and benzaldehyde or benzyl

Table 1.3-1. Summary of Previous Air Quality Monitoring Programs at RMA.

| Contaminant | Sampling Event | Responsible Organization | Reference |
|---|---|---|---|
| TSP | 1969 | Moss, E. | Moss, 1969 |
| | 1969 | USAEHA | USAEHA, 1970 |
| | 1980 | USAEHA | USAEHA, 1981 |
| | Historical | CDH | CDH, 1984 and 1985 |
| Lead, Arsenic, Cadmium, Mercury, Copper | 1980 | USAEHA | USAEHA, 1981 |
| Lead | Historical | CDH | CDH, 1984 and 1985 |
| Sulfur oxides | 1969 | USAEHA | USAEHA, 1970 |
| | Historical | CDH | CDH, 1984 and 1985 |
| Nitrogen oxides | 1969 | USAEHA | USAEHA, 1970 |
| | Historical | CDH | CDH, 1984 and 1985 |
| Ozone | Historical | CDH | CDH, 1984 and 1985 |
| Carbon monoxide | Historical | CDH | CDH, 1984 and 1985 |
| Organic Compounds | 1976 | | RMA 0120 2864 FL |
| | 1977 | | RMA, 1978 |
| | 1978 | Hartman, F. | Hartman, 1979 |
| | 1980 | USAEHA | USAEHA, 1980a |
| | 1980 | NSTL | CSC, 1980 |
| | 1980 | USAEHA | USAEHA, 1980b |
| | 1981 | USAEHA | RMA, 1981 |
| | 1982 | USAEHA | USAEHA, 1982 |
| Hydrochloric Acid | 1969 | USAEHA | USAEHA, 1970 |

Source: ESE, 1988.

alcohol. In January of 1981 (U.S. Army, 1981), the Environmental Division Contamination Migration Branch again sampled the air near Basin F and found the following compounds:

| | |
|---|---|
| Benzene | Hexane |
| Chloroform | 1-Hexanole |
| DCPD | m, o, p-Xylene |
| Diethyl ether | N,N-Dimethylaceto acetamide (NNDMA) |
| DMMP | Toluene. |
| Ethyl benzene | |

An ambient air quality assessment was conducted southeast of Basin F in 1980 (Hanson, 1981). Arsenic, mercury, cadmium, copper, lead, aldrin, dieldrin, and endrin were sampled and analyzed from April to September 1980. During this time arsenic, mercury, cadmium, copper, and lead were detected at low levels. From September through December 1980 the air was sampled for pesticides. Aldrin, endrin, and dieldrin were detected.

In April and May 1982, the USAEHA conducted tests for monitoring airborne emissions from Basin F liquids (USAEHA, 1982, RIC#83192R02). The USAEHA evaluated various adsorption media for collecting Basin F emissions. Although this study did not attempt to characterize ambient air emissions near the basin, the findings indicated the potential for observing the following contaminants:

| | |
|---|---|
| Aldrin | DMMP |
| Bicyclo [2,2,1] heptadiene (BCHD) | Methyl thiocyanate |
| Chloromethylsulfonyl benzene (CMSB) | NNDMA |
| Dichlorobenzonitrile | N-Methyl acetamide |
| Dieldrin | 2-Nitropropane. |
| Dimethyl disulfide (DMDS) | |

Following these tests, the USAEHA sampled the airborne emissions from Basin F from June to August 1982. Evaluation of organic vapor emissions from Basin F detected the following compounds:

| | |
|---|---|
| Aldrin | DMDS |
| Benzene | Endrin |
| CMSB | Hexachlorobicycloheptadiene (HCBCH) |

| | |
|---|---|
| Dichlorobenzonitrile (DCBN) | Hexachlorobutadiene (HCB) |
| Dipropyl amine (DPA) | Isocyanomethane (ICM) |
| DMMP | NNDMA. |
| Dieldrin | |

Based upon these previous investigations and upon current RI activities at RMA, this air monitoring program was initiated. The following sections provide a description of the objectives of the program and an overview of the Air RI Report.

## 1.4 OVERVIEW OF CURRENT INVESTIGATIONS

### 1.4.1 INVESTIGATION OBJECTIVES

The objective of the air monitoring program was to establish a litigation quality data base on the ambient air quality at RMA. The program was designed to support RI/FS activities and, to a lesser extent, support future remedial actions.

Specifically, air quality parameters were monitored to provide data in order to evaluate if there were imminent hazards to public health and the environment, or if these contaminants may have implications on future remedial actions. Likewise, meteorological parameters were measured and evaluated as to their impact on air quality conditions at RMA. Based upon previous air quality investigations, potential contaminant sources, possible future remedial actions, and other RI tasks at RMA, the monitoring program was established under Task 18. The following parameters were monitored:

- o TSP;
- o Particulate Matter less than 10 microns (PM-10);
- o bestos;
- o VOCs;
- o SVOCs; and
- o Metals.

Rationale for monitoring each compound is provided here.

TSP -- The metro-Denver area exceeds the Federal annual TSP standard and RMA is, therefore, in an area of non-attainment for TSP. A non-attainment designation for TSP could severely restrict possible future remedial actions

that may generate particulates. Rather than rely on regional air quality data to characterize RMA, site-specific data was collected to verify the RMA status relative to TSP, and to show that there may be available TSP increment for possible future remedial actions. TSP increment refers to the difference between existing TSP air quality levels and the applicable TSP standard. This increment is the amount of TSP that can be added to the atmosphere without violating Federal and State guidelines. TSP was monitored on a routine basis consistent with Federal Prevention of Significant Deterioration (PSD) guidelines.

PM-10 -- Recently, the EPA passed legislation which replaced the historical particulate standards for TSP with a standard for respirable particulates less than 10 microns (um) in size. In anticipation of this legislation, PM-10 was monitored at RMA to establish PM-10 levels. Verification of onsite PM-10 levels is important for planning future remedial actions in that, similar to TSP, only an available increment of PM-10 contamination may be added to the atmosphere. In order to define that increment, the existing PM-10 levels must be known at RMA. PM-10 was sampled on a routine basis using methodologies that were consistent with anticipated EPA reference methods.

Abestos -- bestos was a common building material at RMA. Because many of the industrial facilities in the South Plants area utilized asbestos and are no longer being maintained, the probability of asbestos becoming airborne is increasing. In order to assure that airborne asbestos levels are not a hazard to human health or that asbestos contamination is not spreading across the RMA environment, asbestos monitoring was initiated on a routine basis. bestos monitoring was conducted according to standard industrial hygiene methods.

VOCs -- Because of past operations at RMA, many organic products and by-products have been released into the RMA environment. Most organics are related to soil and water. Some organics, however, may become airborne and pose a hazard to human health or the environment. In order to evaluate airborne VOCs, monitoring during event conditions was conducted. Experience has shown that most organics have minimal potential for migration even under

the most favorable meteorological conditions. Therefore, meteorological guidelines were outlined and sampling was conducted for VOCs near during conditions which correlated to these guidelines. Basically, conditions were favorable for VOC sampling during:

- o Low wind speeds;
- o Low temperatures;
- o Low relative humidity;
- o Dry conditions with no precipitation; and
- o Stable atmospheric conditions.

Modified EPA reference methods were used to sample and analyze for VOCs as explained in Section 3.0. These methods were certified according requirements outlined in the Task 18 Final Technical Plan (ESE, 19

SVOC -- SVOCs are prevalent in the RMA environment and include many of the pesticides and insecticides at RMA. Because previous investigations indicate that Basin A is a major source of SVOCs, air quality monitoring for SVOCs was conducted in the vicinity of Basin A. Similar to VOC sampling, SVOC sampling was conducted during meteorological conditions favo SVOCs becoming airborne. The events were characterized as follows

- o Moderate to high wind speeds; and
- o Dry conditions with no precipitation.

Again, modified EPA reference methods were used for sampling and analysis of SVOCs. The certification procedures are contained in the Technical Plan

Metals -- Basin A is the most notable source of metals which may become airborne at RMA because it is dry and subject to wind erosion. Many of the metals are associated with particulates and become airborne during dry, high wind conditions similar to SVOC event sampling. Air quality sampling for metals was conducted during favorable event conditions according to standard practices. For arsenic, cadmium, chromium, copper, lead, and zinc, standard particulate collection techniques were followed. Mercury was collected using standard reference methods for collection of mercury vapors. All analyses conformed with EPA procedures for metals analysis and the certification procedures are contained in the Technical Plan.

### 1.4.2 OVERVIEW OF THE REPORT

This Air RI Report is not inconsistent with the EPA requirements for reporting, as found in "Guidelines on Remedial Investigations Under CERCLA" (EPA, 1985). Where appropriate, modifications to the EPA format were made to accommodate special conditions found at RMA.

Section 2.0 contains a brief description of the air quality and climatological/meteorological setting at RMA. Section 3.0 describes the sampling and analyses program with frequent reference to the Task 18 Technical Plan. Section 4.0 describes the nature and extent of potential air contamination at RMA including an evaluation of all air quality data and a description of meteorological conditions during the sampling period. Finally, Section 5.0 contains an assessment of the contaminants found in air at RMA, as well as an assessment of the climatological and meteorological conditions which impact high pollution events. The appendices to this report contain the air quality and meteorological data collected during Task 18.

# 2.0 ENVIRONMENTAL SETTING

This section provides a brief description of the environmental setting at RMA and in the near vicinity of RMA. Specifically, regional air quality is described and the historical climatological and meteorological conditions are summarized.

The urban environmental setting in the Denver metropolitan area has experienced deterioration of air quality over recent years. The region is not in compliance with EPA NAAQS for three of the six criteria pollutants: TSP, CO, and ozone. If the region does not attain the standards for these contaminants, the Denver area may face sanctions and reduced Federal funding. Historical air monitoring data for north Denver show that particulates, CO, and ozone in the vicinity of RMA are above the NAAQS.

The general climate in vicinity of RMA can be characterized by low relative humidity, abundant sunshine, relatively light rainfall, moderate to high wind movement, hot summers, cold winters, and a large daily range in temperature. Historical meterological data collected nearby at Stapleton International Airport (SIA) indicates precipitation is approximately 15 inches per year. The thin atmosphere allows greater penetration of solar radiation. The climate of the region is greatly affected by the orientation of the mountains with respect to general air movements. The prevailing winds at RMA are from the south and south-southwest, paralleling the foothills west of Denver. Wind speeds average about 9 miles per hour (mph) with gusts as high as 65 mph.

The following sections describe the environmental setting in more detail. Emphasis is placed on parameters which may explain contaminant distributions at RMA. Also, emphasis is placed on parameters which may affect future remedial actions.

## 2.1 AIR QUALITY

The Denver metropolitan area has experienced chronic air quality problems in recent years. During stagnant and/or inversion conditions, particulate, CO,

and ozone concentrations have created extremely poor air quality. This problem has generally been associated with motor vehicles. Air pollution also comes from a wide variety of industrial sources located in the Denver area. Major sources include power plants, oil refineries and transfer stations, chemical plants, cement plants, and various agricultural operations. In addition to these sources, substantial emissions occur as a result of motor vehicle activity and wood burning.

The majority of background air quality information for criteria pollutants contained in this section is provided by the Colorado Department of Health Air Pollution Control Division (CDH-APCD), Colorado Air Quality Data Report (CDH, 1984, RIC#85346R01; 1985; and 1987). Table 2.1-1 is a summary of the air quality in the vicinity of RMA.

### 2.1.1 PARTICULATE MATTER

Particulate matter in the atmosphere is a major contributor to the visibility-related problems in both urban and rural areas. In Denver, this is commonly known as the "Brown Cloud", or more appropriately the "Denver Haze" because it is frequently not brown nor is it actually a cloud. The sources of particulates are many: blown dust and sand from roadways, fields, and construction; and coal dust, fly ash, and carbon black from various combustion sources including automobile exhaust. Two increasing sources of particulates that could have a major impact on haze problems are diesel automobiles and wood stoves. These sources emit potentially significant amounts of elemental and organic carbon particles that play a major role in haze phenomena and health effects. Particulates that range in size from less than 0.1 um to 50 um are called TSP. Particles larger than that range tend to settle out of the air.

Primary standards define levels of air quality which the EPA has determined necessary to protect the public health. National secondary standards define levels of air quality which the EPA judges are necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Until recently, the primary Federal standards for particulate matter was for TSP, independent of particle size. The long-term standard was an annual geometric mean not to exceed 75 micrograms of particulates per cubic meter

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2-3

of air (ug/m$^3$). The short-term standard was a 24-hour average of 260 ug/m$^3$ not to be exceeded more than once per year. The 24-hour secondary TSP standard was 150 ug/m$^3$, not to be exceeded more than once per year and the annual secondary standard was 60 ug/m$^3$.

The majority of man-made particulates are in the 0.1- to 10-um diameter range. EPA has revised the particulate standards to account for the deeper inhalability of smaller particles. The new rule was passed July 1, 1987, and went into effect July 31, 1987. This standard applies to particles 10 um or less in diameter. The annual standard for PM-10 is 50 ug/m$^3$ and the 24-hour primary standard is 150 ug/m$^3$. The rule establishes secondary 24-hour and annual standards that are identical in level and form to the primary standard. The new PM-10 standards replace the TSP standards.

Historical data from 1974 to 1984 for Denver in the vicinity of RMA show an average TSP value of 97 ug/m$^3$, and studies done by the Army in 1969 at the boundary of RMA show a maximum 24-hour value of 274 ug/m$^3$ and geometric means ranging from 24 to 72 ug/m$^3$ (USAEHA, 1969, RIC#85184R02). This indicates that there are sources of TSP in the vicinity of RMA and that the NAAQS for TSP is exceeded near RMA. Except for the PM-10 monitoring conducted during this investigation, there are no historical PM-10 data in the vicinity of RMA.

### 2.1.2 CARBON MONOXIDE

Urban atmospheres contain a significant amount of CO which is produced primarily by motor vehicles. In Denver, 75 percent of the CO emissions in 1987 were estimated to be from vehicular sources. The remainder originated from other combustion sources such as heating, incineration, and power generation.

Daily concentration peaks of CO coincide with morning and evening rush hours, indicating that motor vehicle emissions are the major source of CO. The worst CO problems are found when large numbers of slow moving cars congregate, such as during traffic jams. CO can temporarily accumulate to harmful levels, especially in calm weather during autumn and winter, when automobile emissions and fuel combustion for space heating reach their peak.

CO problems are worse in winter due to motor vehicles running less efficiently, increased combustion for space heating, and strong inversion layers developing near the ground, trapping the pollutants on winter nights.

A relatively new source of CO has been introduced into urbanized areas in Colorado in recent years. The wide-spread use of wood for home heating in air tight stoves could contribute up to 16 percent of the total urban CO concentrations according to present calculations (CDH, 1987).

There are two current standards for CO. They are 9 ppm, averaged over a period of 8 hours, and 35 ppm averaged over a 1-hour period. These levels are not to be exceeded more than once per year.

The overall trend for CO around Denver in 1986 was well above the 8-hour average concentration standard. Historical data from 1975 to [illegible] also show similar trends. North Denver is classified as non-attainment for CO because the NAAQS for CO is routinely exceeded. CO has not been monitored at RMA. However, a special study site for CO in Adams County has been established by CDH-APCD during the winter of 1986 to 1987. Study results indicate that the 8-hour CO standard would be violated at this location.

2.1.3 OZONE

Denver's extremely poor air quality is generally blamed on CO and ozone, a highly reactive form of oxygen. Ozone is not emitted directly from a source as are other pollutants, but forms as a secondary pollutant. Precursors of ozone are certain reactive hydrocarbons and nitrogen oxides which chemically react in sunlight to form ozone. The reactive hydrocarbons are emitted in automobile exhaust, from gasoline and oil storage and transfer, and from industrial use of paint solvents, degreasing agents, cleaning fluids, ink solvents, incompletely burned coal or wood, and many other sources. Vegetation also give off some reactive hydrocarbons, for example, terpene from pine trees. Nitrogen oxides are emitted by sources when nitrogen in the air combines with oxygen during high temperature combustion.

Although ozone production is a year-round phenomenon, the highest ozone levels generally occur during the summer season. Strong sunlight and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days.

In 1979, the ozone standard was changed to a statistical form. A calculation is used that accounts for missing days of data, maximum monitored values, and previous data in estimating total yearly violations. The 3-year average of these yearly estimates is the expected number of violations. The standard is attained "...when the expected number of days per calendar year with a maximum hourly average concentrations above 0.12 ppm is equal to or less than one" (CDH, 1984, RIC#85346R01). The ozone standard is currently being studied to change the primary standard to a concentration in the range of 0.08 to 0.14 ppm.

North Denver has been classified as non-attainment for ozone because this area has not complied with the NAAQS. However, a trend of decreasing numbers of ozone violation days during 1975 to 1986 has been noted in the north Denver area. This may be attributed to pollution control strategies being implemented. Ozone has not been monitored at RMA.

### 2.1.4 NITROGEN OXIDES

Nitrogen in the air combines with oxygen during high temperature combustion producing oxides of nitrogen. Most of the nitrogen oxides emitted are nitric oxide. Nitrogen dioxide is formed generally from the oxidation of the more commonly emitted nitric oxide. Nitrogen dioxide is the predecessor of gaseous nitric acid and nitrate aerosols. The relationship between nitrogen oxides and resulting ambient nitrogen dioxide, nitric acid, and nitrate aerosol concentrations is neither direct nor constant. About 48 percent of the emissions of nitrogen oxides in the Denver area come from large combustion sources such as power plants, 37 percent from motor vehicles, 11 percent from space heating, and 4 percent from aircraft. The current standard for nitrogen dioxide is an annual arithmetic mean value not to exceed 0.053 ppm.

No violations of the nitrogen dioxide standard have been recorded in Colorado since 1977. Data from 1969 Army monitoring stations show a maximum 24-hour value of 0.075 ppm at the southern boundary of RMA in 1969 (USAEHA, 1969, RIC#85184R02). The annual average for nitrogen dioxide at RMA is expected to be much less than this 24-hour maximum value because there are no major combustion sources at RMA. The annual NAAQS is not expected to be exceeded at RMA.

### 2.1.5 SULFUR OXIDES

Sulfur dioxide is considered to be one of the major pollution problems on a worldwide basis. It is emitted mainly from stationary sources that burn fossil fuels such as coal and oil. There are two existing primary NAAQS for sulfur dioxide. The first is an annual arithmetic average of 0.03 ppm. The second is a 24-hour average standard where concentrations are not to exceed 0.14 ppm more than once per year. The current secondary NAAQS for sulfur dioxide is a 3-hour average concentration of 0.5 ppm not to be exceeded more than once per year.

Historical sulfur dioxide data for the Denver area shows that sulfur dioxide has not been a problem and no standards have been exceeded. Background data from the Army's air monitoring in 1969 show 0.32 ppm of sulfur dioxide as a maximum 24-hour value which was measured on the northern boundary when the wind was blowing in a northeastern direction (USAEHA, 1969, RIC#85184R02). Because most sulfur dioxide values were less than detection limits at all stations, the Army reported geometric means of less than detection limits at each of the nine stations. Currently there are no significant sources of sulfur dioxide at RMA.

### 2.1.6 LEAD

Airborne metals exist primarily as particulate matter in the inhalable size range and may cause adverse health effects when inhaled. One of these metals is lead which exists in the atmosphere and is predominately produced by vehicles that burn leaded gasoline. Lead is the only metal which is a criteria pollutant according to EPA. The current standard for lead is a 3-month average concentration not to exceed 1.5 ug/$m^3$.

Since 1979, there have been no violations of the lead standard in the Denver area. Historical data for lead in the vicinity of RMA indicates concentrations of 0.5 to 1.0 ug/m$^3$, but a significant decline has been realized in the last 5 years with the introduction of lead-free gasoline. The Army monitored lead concentrations at the boundary of RMA and at the interior of the site in 1980. The annual geometric average concentrations ranged from 0.13 to 0.26 ug/m$^3$ (USAEHA, 1981, RIC#81293R04).

## 2.2 CLIMATOLOGY AND METEOROLOGY

RMA is located at the western edge of the plains of Colorado and near the foothills of the mountains. The area is generally classified as mid-latitude and semi-arid. Tables 2.2-1 through 2.2-4 are a summary of climatological and meteorological data in the RMA vicinity. Data were collected at SIA, which is adjacent to RMA. Because of the close proximity and relatively uniform topography between SIA and RMA, the climatological and meteorological conditions are expected to be approximately the same between two sites.

The climate of this area has characteristic features of low relative humidity, abundant sunshine, relatively light rainfall, moderate to high wind movement, and a large daily range in temperature. As shown in Table 2.2-1, the mean maximum temperatures range from 43 degrees Fahrenheit ($^{o}$F) in January to 88$^{o}$F in July. The mean minimum temperatures are 16$^{o}$F in January and 59$^{o}$F in July. On the average, the mean annual maximum and minimum temperatures may vary by 28$^{o}$F.

Occasionally, a meterological phenomenon, known as the Chinook winds, descends along the eastern slope of the State from the southwest. These winds bring large and sudden temperature rises, as much as 25$^{o}$ to 35$^{o}$F within a few hours. Chinook winds greatly moderate average winter temperatures in the RMA vicinity.

As a result of Colorado's distance from major sources of moisture, such as the Pacific Ocean and the Gulf of Mexico, precipitation is relatively light in lower elevations. Storms originating in the Pacific and moving eastward lose much of their moisture as they pass over mountain ranges in western

Table 2.2-1. Summary of Temperature Data in the Vicinity of the Rocky Mountain Arsenal.

| Month | Temperatures (°F) | | | | | | | Mean Number of Days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal† | | | Extremes† | | | | Max | | Min. | |
| | Daily Maximum | Daily Minimum | Monthly | Record Highest | Year | Record Lowest | Year | 90°F and above** | 32°F and below | 32°F and below | 0°F and below |
| | | | | 49* | | 49* | | 23* | 23* | 23* | 23* |
| J | 43.1 | 15.9 | 29.5 | 73 | 1982 | -25 | 1963 | 0 | 7 | 30 | 4 |
| F | 46.9 | 20.2 | 33.6 | 76 | 1963 | -30 | 1936 | 0 | 4 | 26 | 2 |
| M | 51.2 | 24.7 | 38.0 | 84 | 1971 | -11 | 1943 | 0 | 3 | 25 | 1 |
| A | 61.0 | 33.7 | 47.4 | 85 | 1960 | -2 | 1975 | 0 | — | 12 | — |
| M | 70.7 | 43.6 | 57.2 | 96 | 1942 | 22 | 1954 | — | 0 | 2 | 0 |
| J | 81.6 | 52.4 | 67.0 | 104 | 1936 | 30 | 1951 | 6 | 0 | 0 | 0 |
| J | 88.0 | 58.7 | 73.3 | 104 | 1939 | 43 | 1972 | 15 | 0 | 0 | 0 |
| A | 85.8 | 57.0 | 71.4 | 101 | 1938 | 41 | 1964 | 9 | 0 | 0 | 0 |
| S | 77.5 | 47.7 | 62.6 | 97 | 1960 | 20 | 1971 | 2 | 0 | 1 | 0 |
| O | 66.8 | 36.9 | 51.9 | 88 | 1947 | 3 | 1969 | 0 | — | 8 | — |
| N | 52.4 | 25.1 | 38.7 | 79 | 1941 | -8 | 1950 | 0 | 2 | 24 | — |
| D | 46.1 | 18.9 | 32.6 | 75 | 1980 | -21 | 1983 | 0 | 5 | 29 | 3 |
| YR | 64.3 | 36.2 | 50.3 | 104 | July 1939 | -30 | Feb. 1936 | 33 | 22 | 158 | 9 |

* Length of record, years, through the current year unless otherwise noted, based on January data.
† Normals - Based on record for the 1951 - 1980 period.
Extremes - Length of record may be for other t[illegible]n complete or consective data years. Date is the most recent in cases of multiple occurrences.
** 70° and above at Alaska Stations.

Source: Ruffner, 1985

Table 2.2-2. Summary of Precipitation and Humidity Data in the Vicinity of the Rocky Mountain Arsenal.

| Month | Precipitation (inches) Water equivalent Normal† | Maximum Monthly | Year | Minimum Monthly | Year | Maximum in 24 hrs. | Year | Snow, Ice pellets Maximum monthly | Year | Maximum in 24 hrs. | Year | Relative Humidity Pct. 05 hour (local time) | 11 hour | 17 hour | 23 hour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 49* | | 49* | | 49* | | 49* | | 49* | | 23* | 23* | 23* | 23* |
| J | 0.51 | 1.44 | 1948 | 0.01 | 1952 | 1.02 | 1962 | 23.7 | 1948 | 12.4 | 1962 | 63 | 46 | 49 | 63 |
| F | 0.69 | 1.66 | 1960 | 0.01 | 1970 | 1.01 | 1953 | 18.3 | 1960 | 9.5 | 1953 | 66 | 43 | 42 | 64 |
| M | 1.21 | 4.56 | 1983 | 0.13 | 1965 | 2.79 | 1983 | 30.5 | 1983 | 18.0 | 1983 | 67 | 42 | 41 | 64 |
| A | 1.81 | 4.17 | 1942 | 0.03 | 1963 | 3.25 | 1967 | 28.3 | 1935 | 17.3 | 1957 | 67 | 37 | 34 | 58 |
| M | 2.47 | 7.31 | 1957 | 0.06 | 1974 | 3.55 | 1973 | 13.6 | 1950 | 10.7 | 1950 | 70 | 40 | 38 | 61 |
| J | 1.58 | 4.69 | 1967 | 0.09 | 1960 | 3.16 | 1970 | 0.3 | 1951 | 0.3 | 1951 | 70 | 37 | 35 | 59 |
| J | 1.93 | 6.41 | 1965 | 0.17 | 1939 | 2.42 | 1965 | 0.0 | | 0.0 | | 68 | 35 | 34 | 56 |
| A | 1.53 | 5.85 | 1979 | 0.06 | 1960 | 3.43 | 1951 | 0.0 | | 0.0 | | 69 | 37 | 35 | 58 |
| S | 1.23 | 4.67 | 1961 | T** | 1944 | 2.44 | 1936 | 21.3 | 1936 | 19.4 | 1936 | 68 | 37 | 34 | 59 |
| O | 0.98 | 4.17 | 1969 | 0.05 | 1962 | 1.71 | 1947 | 31.2 | 1969 | 12.4 | 1969 | 64 | 36 | 35 | 58 |
| N | 0.82 | 2.97 | 1946 | 0.01 | 1949 | 1.29 | 1975 | 39.1 | 1946 | 15.9 | 1983 | 68 | 44 | 49 | 65 |
| D | 0.55 | 2.84 | 1973 | 0.03 | 1977 | 2.00 | 1982 | 30.8 | 1973 | 23.6 | 1982 | 64 | 45 | 51 | 63 |
| YR | 15.31 | 7.31 | MAY 1957 | T | SEPT 1944 | 3.55 | MAY 1973 | 39.1 | NOV 1946 | 23.6 | DEC 1982 | 67 | 40 | 40 | 60 |

* Length of record, years, through the current year unless otherwise noted, based on January data.
† Normals - Based on record for the 1951-1980 period.
Maximum - Length of record may be for other than complete or consective data years. Date is the most recent in cases of multiple occurrences.
** T = Trace; blank entries denote missing or unreported data.

Note: Normal cooling degree data published in the 1982 Annual were for the 1951-1980 period.

Source: Ruffner, 1985

Table 2.2-3. Summary of Wind and Pressure Data in the Vicinity of the Rocky Mountain Arsenal.

| | Wind† | | | | | Average station pressure mb. |
|---|---|---|---|---|---|---|
| | | Thru 1968 | Fastest mile | | | elevation |
| Month | Mean Speed (m.p.h.) | Prevailing direction | Speed (m.p.h.) | Direction | Year | 5332 ft msl |
| | 35* | 15* | 31* | 31* | | 11 |
| J | 8.8 | S | 53 | N | 1976 | 833.9 |
| F | 9.1 | S | 49 | NW | 1953 | 834.2 |
| M | 9.9 | S | 53 | NW | 1952 | 831.1 |
| A | 10.2 | S | 56 | NW | 1960 | 833.2 |
| M | 9.4 | S | 54 | SE | 1978 | 833.9 |
| J | 9.0 | S | 47 | S | 1956 | 836.2 |
| J | 8.4 | S | 56 | SW | 1965 | 838.9 |
| A | 8.1 | S | 42 | N | 1978 | 838.9 |
| S | 8.1 | S | 47 | NW | 1955 | 838.6 |
| O | 8.0 | S | 45 | NW | 1958 | 837.7 |
| N | 8.5 | S | 48 | W | 1962 | 835.5 |
| D | 8.8 | S | 51 | NE | 1953 | 834.5 |
| YR | 8.8 | S | 56 | SW | 1965 (July) | 835.6 |

* Length of record, years, through the current year unless otherwise noted, based on January data.
Means- Length of record is for complete data years.
Wind Direction - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
Fastest Mile Wind - Speed is fastest observed in 1-minute value when direction is in tens of degrees.

Fastest mile winds are through August 1981.
Means and extremes above are from existing and comparable exposures. Area extremes have been exceeded at other sites in the locality as follows:
Wind - Fastest mile: 65 W in May 1933.

Source: Ruffner, 1985.

Table 2.2-4. Summary of Meteorological Data in the Vicinity of the Rocky Mountain Arsenal.

| | | | Mean Number of Days | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Pct. of possible sunshine | Mean sky cover, tenths, sunshine to sunset | Sunrise to Sunset Clear | Partly Cloudy | Cloudy | Precipitation 0.01 inch or more | Snow, Ice pellets 1.0 inch or more | Thunderstorms | Heavy fog, visibility ¼ mile or less |
| | 34* | 35* | 49* | 49* | 49* | 49* | 49* | 49* | 43* |
| J | 72 | 5.6 | 10 | [illegible] | 12 | 6 | 2 | 0 | 1 |
| F | 71 | 5.9 | 8 | 8 | 12 | 6 | 2 | - | 2 |
| M | 70 | 6.1 | 8 | 10 | 13 | 9 | 4 | - | 1 |
| A | 68 | 6.0 | 7 | 11 | 12 | 9 | 3 | 1 | 1 |
| M | 64 | 6.3 | 6 | 12 | 13 | 11 | -** | 6 | 1 |
| J | 71 | 5.0 | 10 | 12 | 8 | 9 | 0 | 10 | - |
| J | 72 | 4.9 | 9 | 16 | 6 | 9 | 0 | 11 | - |
| A | 72 | 4.9 | 10 | 14 | 7 | 9 | 0 | 8 | 1 |
| S | 75 | 4.3 | 13 | 10 | 7 | 6 | - | 3 | 1 |
| O | 73 | 4.5 | 13 | 10 | 8 | 5 | 1 | 1 | 1 |
| N | 65 | 5.4 | 10 | 10 | 10 | 5 | 2 | - | 1 |
| D | 67 | 5.4 | 11 | 9 | 11 | 5 | 2 | 0 | 1 |
| YR | 70 | 5.4 | 115 | 131 | 119 | 88 | 18 | 41 | 10 |

*Length of record, years, through the current year based unless otherwise noted, based on January data.
**Less than one half.

Source: Ruffner, 1985.

Colorado. Eastern areas of the state receive small amounts of precipitation from these storms. Storms moving from the north usually carry little moisture. The frequency of such storms increases during the fall and winter months, and decreases rapidly in the spring. Warm, moist air from the south reaches the RMA vicinity most frequently in the spring. Frequent showers and thunderstorms continue well into the summer. In the summer months, winds from the southwest can bring hot, dry air into the area for a short duration.

Precipitation in the RMA vicinity is approximately 15 inches per year with approximately half of the precipitation falling between April and July, as shown in Table 2.2-2. Snow and sleet usually occur from September to May with the heaviest snowfall in March and possible accumulations as late as June. Thunderstorms occur frequently in the region, particularly during the spring and summer. They may be severe and are generally accompanied by heavy showers, severe gusty winds, frequent thunder and lightning, and occasional hail. There are approximately 93 days per year with a cloud cover of 30 percent of less.

The prevailing winds at RMA are from the south and south-southwest, paralleling the orientation of the foothills west of Denver. Wind speeds average about 9 mph annually (Table 2.2-3 and Figure 2.2-1). Occasional winds are also out of the north-northwest, north, and east. The windy months are March and April, with gusts as high as 65 mph. These months come immediately after the driest months of the year (November through February) and have the highest potential for dust storms.

Early morning inversions over the Denver metropolitan area are common, but they rarely persist through the day. During inversion episodes, the atmosphere is stable. This prevents mixing and causes accumulation of pollutants. Nearly 60 percent of the year, Denver experiences stable atmospheric conditions which favor air pollution events. The majority of stable or stagnant conditions are observed during the winter.

Another factor which contributes to high air pollution in Denver is the daily back and forth motion of air along the Front Range. The metropolitan

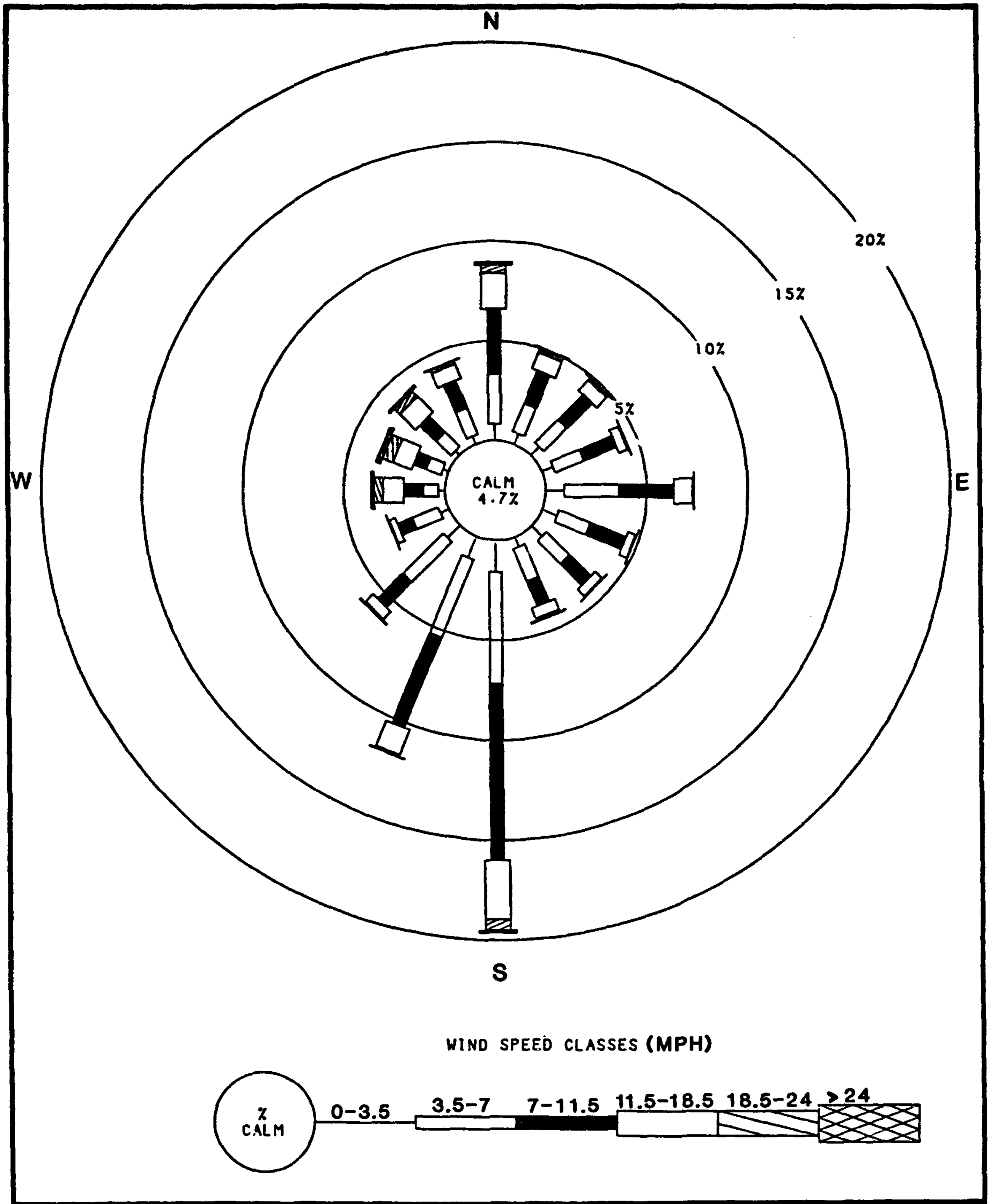



Figure 2.2-1
ANNUAL WIND ROSE FOR RMA VICINITY
(STAPLETON INTERNATIONAL AIRPORT 1975-1979)
SOURCE: ESE. 1988

**Prepared for:**
**U.S. Army Program Manager's Office For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

T18D-AR-004

area is in the South Platte River basin with decreasing elevation towards the northeast. Cold, heavy air drains toward the northeast at night and during early morning hours. As the atmosphere warms during the afternoon, the flow reverses sharply. Much of the air that had traversed the city earlier, going downslope as clean air, reenters Denver as polluted air going upslope to the south.

Because Denver is at a high altitude, the atmosphere is thin which allows greater penetration of solar radiation. The ultraviolet light can interact with airborne contaminants. Chemical reactions initiated by photochemical processes increase Denver's smog problem, particularly the conversion of nitrogen oxides and hydrocarbons into ozone.

Table 2.2-4 summarizes other meteorological and climatological conditions near RMA. The data presents the number of days that certain conditions are normally observed.

# 3.0 SAMPLING AND ANALYSES PROGRAM

The procedures for collection and analyses of air samples are described in detail in the Task 18 Final Technical Plan (ESE, 1987). The methods for collection of meteorological data are also contained in the Technical Plan. This section provides a brief overview of the sampling and analyses program with emphasis on actual field procedures that were utilized versus the procedures contained in the Technical Plan. Appendix A contains a list of specific deviations of field activities as compared to the planned approach in the Technical Plan.

## 3.1 AIR QUALITY

### 3.1.1 SAMPLING TECHNIQUES

Air samples were collected from permanent and mobile air quality stations on RMA. Figure 3.1-1 shows the locations of the permanent stations on the perimeter of RMA and near Basins A and F, the South Plants, the North Plants, and the Rail Classification Yard. Portable air quality stations were also used and their locations were dependent on high-event conditions following criteria set in the Technical Plan. All stations, including portable locations, were documented and surveyed by a registered surveyor. Table 3.1-1 contains a description of the surveyed locations of the monitoring stations.

All but four of the 12 permanent Air Quality (AQ) stations were located in the original sites designated by the Technical Plan. Initially, AQ4, AQ5, AQ6, and AQ10 required portable propane generators for power supply. However, frequent generator equipment failure resulted in missed sampling events at these sites. AQ5 and AQ6 were relocated to nearby sites where line electricity was available and sampling was continued. Generator failures were realized at stations AQ4 and AQ10 on a continuing basis, and line electricity could not be supplied from the surrounding areas. Therefore, sampling efforts were discontinued at AQ4 and AQ10.

The sampling strategy outlined in the Technical Plan was utilized in the collection of baseline and event data (Table 3.1-2). The baseline 6-day sampling schedule set forth by the CDH-APCD is shown in the Technical Plan.

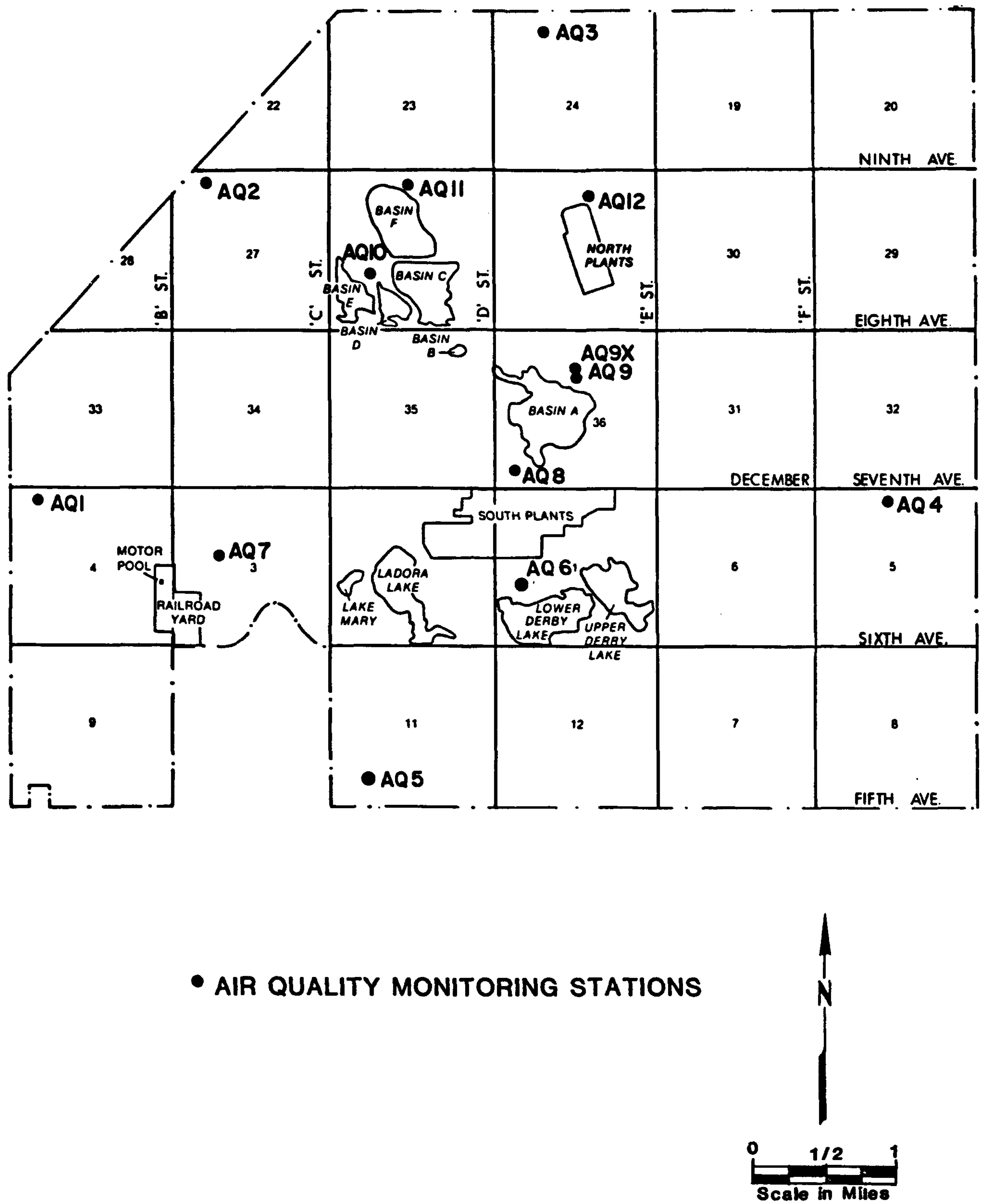



Figure 3.1-1
AIR QUALITY MONITORING STATIONS
ROCKY MOUNTAIN ARSENAL
SOURCE: ESE, 1988

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

T18D-AR-005

Table 3.1-1. Surveyed Locations of Monitoring Stations

| Station | Coordinates Northing | Coordinates Easting | Elevation (ft) |
|---|---|---|---|
| Permanent Air Quality Monitoring Stations | | | |
| AQ1 | 177,395.46 | 2,176,628.86 | 5,209.34 |
| AQ2 | 190,950.25 | 2,173,808.13 | 5,131.03 |
| AQ3 | 195,895.65 | 2,185,671.67 | 5,141.14 |
| AQ4 | 180,536.12 | 2,196,630.92 | 5,299.22 |
| AQ5 | 171,280.04 | 2,189,092.21 | 5,296.40 |
| AQ6 | 176,895.50 | 2,182,651.67 | 5,264.72 |
| AQ7 | 178,246.45 | 2,174,165.98 | 5,196.10 |
| AQ8 | 180,741.57 | 2,184,793.38 | 5,263.93 |
| AQ9 | 184,704.84 | 2,185,543.99 | 5,252.25 |
| AQ9x | 184,704.84 | 2,185,543.99 | 5,252.25 |
| AQ10 | 187,562.45 | 2,179,454.03 | 5,188.95 |
| AQ11 | 190,718.88 | 2,180,794.30 | 5,185.55 |
| AQ12 | 190,620.16 | 2,186,724.88 | 5,186.02 |
| Mobile Air Quality Monitoring Stations | | | |
| BF1 | 189,611.67 | 2,181,398.92 | 5,207.50 |
| BF2 | 189,770.74 | 2,181,325.76 | 5,209.70 |
| BF3 | 190,014.13 | 2,181,166.36 | 5,208.07 |
| BF4 | 190,103.30 | 2,181,098.48 | 5,206.58 |
| BF5 | 190,512.45 | 2,180,665.55 | 5,195.94 |
| BF6 | 190,655.54 | 2,180,730.70 | 5,188.93 |
| BF7 | 190,685.77 | 2,180,011.87 | 5,199.17 |
| BF8 | 190,653.06 | 2,179,805.06 | 5,195.02 |
| BF9 | 190,402.77 | 2,179,435.18 | 5,199.09 |
| BF10 | 190,030.36 | 2,179,333.40 | 5,198.70 |
| BF11 | 189,208.73 | 2,179,575.15 | 5,201.94 |
| BF12 | 188,650.81 | 2,179,867.62 | 5,206.24 |
| BF13 | 188,193.89 | 2,180,107.41 | 5,206.67 |
| BF14 | 188,190.17 | 2,180,337.69 | 5,208.10 |
| BF15 | 188,100.96 | 2,182,480.07 | 5,207.80 |
| BF16 | 188,214.18 | 2,181,513.66 | 5,210.89 |
| BA1 | 180,543.74 | 2,186,214.94 | 5,261.51 |
| BA2 | 180,823.51 | 2,187,046.11 | 5,254.42 |
| BA3 | 180,832.16 | 2,184,806.72 | 5,261.99 |
| BA4 | 184,650.36 | 2,185,621.89 | 5,247.46 |
| BA5 | 184,714.07 | 2,185,421.58 | 5,249.02 |
| Meteorological Monitoring Stations | | | |
| M-1 | 191,026.29 | 2,182,433.75 | 5,197.24 |
| M-2 | 190,523.44 | 2,186,253.75 | 5,193.52 |
| M-3 | 180,733.70 | 2,187,493.06 | 5,262.83 |

Source: ITECH, 1986-87.

Table 3.1-2. Air Quality Sampling Frequencies

| Parameter | Type of Sampling | Frequency | Monitoring Duration | Sample Locations | Number of Samples Planned | Number of Samples Actual |
|---|---|---|---|---|---|---|
| TSP | Baseline | Every 6th Day | 24-Hour | AQ1-12 | 732 | 574 |
| PM-10 | Baseline | Every 6th Day | 24-Hour | AQ2, 5, 9 | 183 | 80 |
| Asbestos | Baseline | Every 2 Weeks | 8-Hour | AQ1, 6, 8, 12 | 104 | 103 |
| VOC | Event | 6 Event Days | 2-Hour | Eight mobile monitoring locations per sampling event. | 48 | 47 |
| SVOC | Event | 6 Event Days | 8-Hour | Four mobile monitoring locations per sampling event. | 24 | 16 |
| Metals | Event | 12 Event Days | 24-Hour | AQ1, 3, 4, 5, and four mobile monitoring locations per sampling event. | 96 | 93 |
| Arsenic | Event | 12 Event Days | 24-Hour | AQ1, 3, 4, 5, and four mobile monitoring locations per sampling event. | 96 | 93 |
| Mercury | Event | 12 Event Days | 8-Hour | AQ1, 3, 4, 5, and four mobile monitoring locations per sampling event. | 96 | 62 |

Source: ESE, 1987.

Event sampling was conducted only under preferable sampling conditions consistent with criteria set forth in the Technical Plan. The sampling conditions for each event are documented on the data summary tables found in Section 4.0.

The sampling techniques used in the collection of particulate and toxic airborne contaminants were based on reference methods proposed in the Technical Plan. However, a modification was made to the VOC sampling train. The train was not placed in a ventilated housing unit due to insufficient power for the air intake fan. The results of sampling were not considered to be affected by this modification.

3.1.2 ANALYTICAL PROCEDURES

The sample analysis program was based upon recognized reference methods as given in the Technical Plan. Table 3.1-3 lists the parameters and their respective chemical analyses. Methods for the analysis of metals, VOCs, and SVOCs were certified by the Program Manager's Office (PMO)- RMA/USATHAMA. Appendix C of the Technical Plan contains certification procedures. The analysis of TSP, PM-10, and asbestos followed standard EPA and National Institute of Occupational Health and Safety (NIOSH) analytical methods which did not require certification.

TSP and PM-10 concentrations were determined by pre- and post-sample weighing of filters and correlating net sample weights with the volume of air sampled. All concentrations of particulates were corrected to standard temperature and pressure. Particulate data was reported in geometric average annual and monthly concentrations for each site.

Asbestos samples were analyzed according to NIOSH Method 7400 using "A" Counting Rules. The method uses phase contrast microscopy (PCM) to count fibers greater than 5 um in length and having a length to width aspect ratio of at least 3 to 1. A fiber concentration of 0.01 fibers per cubic centimeter of air was the limit of detection.

VOCs and SVOCs were analyzed by gas chromatography/mass spectrometry (GC/MS) with a library search. Target VOCs and target SVOCs are presented in Tables 3.1-4 and 3.1-5, respectively. The reporting limits were calculated

Table 3.1-3. Laboratory Analysis Methods.

| Parameter | Collection Media | Certification | Reference Methods | Method |
|---|---|---|---|---|
| TSP | Filter | None | 40 CFR Part 50 Appendix B | Gravimetric |
| PM-10 | Filter | None | 40 CFR Part 50* Appendix B | Gravimetric |
| Asbestos | Filter | None | NIOSH 7400 | Phase Contrast Microscopy |
| VOC | Tenax® GC Tubes | Semiquantitative | EPA TO-1 | GC/MS** Library Search |
| SVOC | PUF Cartridge | Semiquantitative | EPA TO-4 | GC/MS Library Search |
| Metals | Filter | Quantitative | NIOSH 7300 | ICAP† |
| Arsenic | Filter | Quantitative | EPA Method 206.2, 1978 | AA-Graphite†† Furnace |
| Mercury | Hopcalite® Charcoal | Quantitative | AIHA, 1976 | AA-Cold Vapor |

* PM-10 sampling was performed in accordance with the guidelines for high volume sampler operation given in EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II. Ambient Air Specific Methods.

** Gas Chromatography/Mass Spectrometry.

† Inductively Coupled Argon Plasma Emission Spectroscopy.

†† Atomic Absorption Spectroscopy.

Source: ESE, 1987.

Table 3.1-4. Target Volatile Analytes.

| Compound | EPA Ambient Air Method |
|---|---|
| BCHD | |
| Benzene | TO-1 |
| Carbon tetrachloride | TO-1 |
| Chlorobenzene | TO-1 |
| Chloroform | TO-1 |
| 1,1-Dichloroethane | |
| 1,2-Dichloroethane | TO-1 |
| trans-1,2-Dichloroethylene | |
| DMDS | |
| Ethylbenzene | TO-1 |
| Methylene chloride | |
| Methylisobutyl ketone (MIBK) | |
| N-Nitrosodimethylamine (NDMA) | |
| Tetrachloroethylene | TO-1 |
| Toluene | TO-1 |
| 1,1,1-Trichloroethane | |
| 1,1,2-Trichloroethane | |
| Trichloroethylene | |
| m-Xylene | TO-1 |
| o-Xylene | |
| p-Xylene | |

Source: ESE, 1987.

Table 3.1-5. Target Semivolatile Analytes.

| Compound | EPA Ambient Air Method |
|---|---|
| Aldrin | TO-4 |
| Atrazine | |
| Chlordane | TO-4 |
| CPMS | |
| CPMSO | |
| $CPMSO_2$ | |
| DBCP | |
| DCPD | |
| 4,4'-DDE | |
| 4,4'-DDT | TO-4 |
| Dieldrin | TO-4 |
| DIMP | |
| Dithiane | |
| DMMP | |
| Endrin | |
| HCCPD | |
| Isodrin | |
| Malathion | |
| Oxathiane | |
| Parathion | |
| Supona | |
| Vapona | |

Source: ESE, 1987.

using the Hubaux and Vos procedure and were not lower than the lowest spiked sample. Nontarget VOCs and SVOCs were identified, where possible, and reported. In the summary tables, the compounds were identified but concentrations were not given as the accuracy of the concentration of nontarget analytes is not certain.

Analysis for metals determined concentrations of cadmium, chromium, copper, lead, zinc, arsenic, and mercury. The reporting limits for metals were determined by the PMO-RMA/USATHAMA reporting limit program and were not lower than the lowest spiked sample.

### 3.1.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) for all sampling and analysis activities was consistent with the Field/Laboratory QA Plan given in Appendix D of the Technical Plan and with the specific RMA QA requirements given in Section 4.0 of the Technical Plan. The Project QA Supervisor and the QA Coordinators assured the technical quality of the data through monitoring and periodic auditing of quality control procedures followed by the field sampling teams and laboratory personnel.

The field operations that were audited include sample handling, use of sample containers for specific analyses, use of approved sampling techniques to minimize loss of sample, and field documentation and chain-of-custody practices. Sample collection preparation was monitored as part of the laboratory audit. The Laboratory QA Coordinator assured compliance with the holding time and preservation requirements for the samples requiring analysis by certified methods.

All data were processed through the Data Management System and Project QA Staff as directed by the Field/Laboratory QA Plan. QA Program Status Reports were submitted upon completion of each analytical lot to PMO-RMA/USATHAMA. All points which indicated an out-of-control situation were evaluated and explained in the status reports. Necessary corrective action to prevent recurrence also was addressed at this time.

## 3.2 METEOROLOGY

### 3.2.1 SAMPLING TECHNIQUES

Onsite meteorological parameters were monitored at the three 10-meter stations shown in Figure 3.2-1. Table 3.1-1 contains the exact locations as determined by a registered surveyor. The National Climatic Center (NCC) also monitors meteorological conditions at SIA, less than 2 miles from RMA.

The onsite stations were established in 1981 and have been maintained by RMA. Prior to commencement of Task 18, the stations were experiencing problems with data retrieval because of erratic Data Acquisition System (DAS) operation and unreliable power supply systems. As part of Task 18, station M1 was retrofitted to have a self-contained DAS and battery power supply. In addition to sending data to the RMA computer network, M1 collected and stored data at the station. M2 and M3 continued to send data to the computer network at South Plants.

The meteorological parameters that were monitored included:

- o Barometric pressure;
- o Precipitation;
- o Solar radiation;
- o Standard deviation of wind direction (sigma theta);
- o Temperature;
- o Wind direction; and
- o Wind speed.

### 3.2.2 ANALYTICAL PROCEDURES

Monitoring sensors were fixed on 10-meter meteorological stations or at the base of the stations. Wind speed and direction were used to select sampling days and identify event periods favorable for collection of contaminants. Temperature and barometric pressure were important parameters necessary for standardization of air quality data.

Data were stored at the meterological station M1 and at South Plants for M1, M2, and M3. The DAS at M1 is a battery powered microcomputer with a time clock, a serial data interface, and a programmable analog-to-digital (A/D) converter. Each minute, the DAS records the incoming signals according to

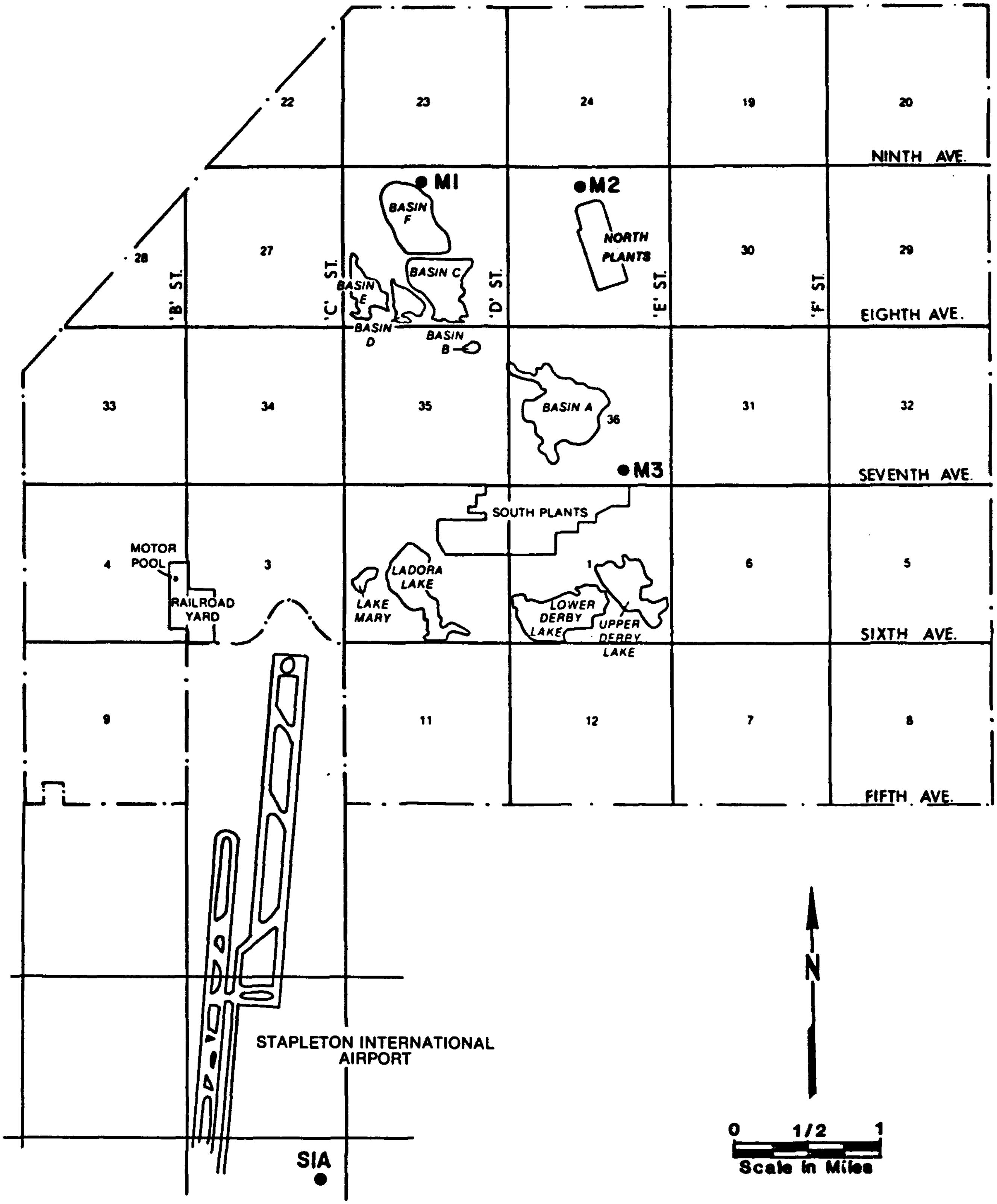



Figure 3.2-1
METEOROLOGICAL MONITORING STATIONS AT ROCKY MOUNTAIN ARSENAL AND STAPLETON INTERNATIONAL AIRPORT
SOURCE: ESE, 1988

**Prepared for:**
**U.S. Army Program Manager's Office For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

T18D-AR-006

input programs specified in a user-entered input table. The DAS then processes the data and stores it according to output programs specified in a user-entered output table. Input programs specify the type of signal conditioning and A/D conversions to be done, including linearization of selected input signals. Output programs further process the sensor outputs to obtain the standard parameters listed above and standard deviation of wind speed.

The sensor output signals from M1, M2, and M3 were sent via telephone line to an onpost computer at RMA. The data were filed on magnetic tape for future access. The data were averaged for 15-minute and 24-hour intervals, and were printed weekly from 0000 hours Saturday to 2400 hours Friday. The data were printed the following Monday to be reviewed, compared with strip chart data, and filed.

### 3.2.3 QUALITY ASSURANCE/QUALITY CONTROL

The meteorological monitoring sensors were factory calibrated and were recalibrated either in the field or at the factory. In addition to calibration, equipment was routinely inspected and repaired, as necessary.

On a more frequent schedule, monitoring sensors and DAS were checked against calibrated field check sensors and compared to data collected at the NCC station at SIA. Each month, sensors were checked against calibrated instruments. Wind speed sensors were compared to a calibrated rotation device. Wind direction was checked in the north, south, east, and west directions. Temperature was checked against a NBS-traceable thermometer and periodically compared to readings at SIA. Barometric pressure was also checked against readings from SIA. Solar radiation and precipitation monitoring instruments were compared against field observations. Sunrise and sunset times were used to verify operation of solar radiation monitors.

Data from the tipping-bucket precipitation gauge were compared with observed rain or snowfall events. Precipitation sensors were also correlated with SIA data.

Because the field checks do not constitute formal calibration of equipment, monitoring sensors were not adjusted if minor differences existed between the sensors and the check source. However, minor deviations were noted and filed. If significant differences existed between monitoring equipment and check sources, the sensors were inspected and, if necessary, returned to the vendor for adjustment and calibration.

# 4.0 NATURE AND EXTENT OF CONTAMINATION

This section describes the results of the year-long air quality monitoring program at RMA. For the parameters such as TSP, PM-10, and asbestos that were monitored on a routine basis, trends are shown and explained. For toxic air parameters, such as VOCs, SVOCs, and metals, that were monitored during event conditions, the data from each event is presented and discussed.

For climatological and meteorological parameters, there is a brief discussion of the monitoring program. Meteorological conditions are correlated with event sampling for toxic air contaminants.

Data summary tables, figures, and graphs are presented in this section. The analytical data and detailed summaries are contained in Appendices B, C, and D.

## 4.1 AIR QUALITY PARAMETERS

As part of the air quality monitoring program, routine sampling as well as event sampling was conducted. The results of routine sampling are contained in Section 4.1.1 and the results of event sampling are contained in Section 4.1.2.

### 4.1.1 ROUTINE SAMPLING

TSP and PM-10 were monitored every 6 days according to the Federal monitoring program. Asbestos was monitored every 12 days. The following sections present the data collected and summarize the trends according to monthly averages.

#### 4.1.1.1 Total Suspended Particulates

The TSP data collected at RMA from June 1986 to June 1987 at the 12 air quality stations are summarized in Table 4.1-1 and Figures 4.1-1 and 4.1-2. Appendices B and C contain the raw TSP data as well as summaries. In general, annual geometric average TSP levels were lowest at the stations on the interior of the site. Higher concentrations were realized at the

Table 4.1-1. TSP Data Summary

| Station No. | Location | Concentration (ug/m³) Annual Geometric Average* | Range of Individual 24-Hour Samples* |
|---|---|---|---|
| AQ1 | West Boundary | 46.8 | 7.1-143.3 |
| AQ2 | Northwest Boundary | 46.9 | 11.5-111.9 |
| AQ3 | North Boundary | 30.6 | 4.4-80.5 |
| AQ4 | East Boundary | 42.9** | 38.5-46.8 |
| AQ5 | South Boundary | 35.0** | 5.7-109.1 |
| AQ6 | South of South Plants | 33.1** | 6.2-151.4 |
| AQ7 | East of Rail Class. Yd. | 33.0 | 6.2-100.8 |
| AQ8 | South of Basin A | 34.3 | 7.3-95.1 |
| AQ9 | North of Basin A | 31.5 | 5.4-81.5 |
| AQ9x | North of Basin A | 29.6 | 6.6-83.4 |
| AQ10 | South of Basin F | 28.1 | 5.9-70.7 |
| AQ11 | North of Basin F | 33.5 | 5.6-90.8 |
| AQ12 | North of North Plants | 30.8 | 5.8-77.1 |

| *Federal/State TSP Standards: | Primary | Secondary |
|---|---|---|
| Annual - | 75 $ug/m^3$ | 60 $ug/m^3$ |
| 24-hour - | 260 $ug/m^3$ | 150 $ug/m^3$ |

**Less than 75 percent data recovery due to equipment or power failure.

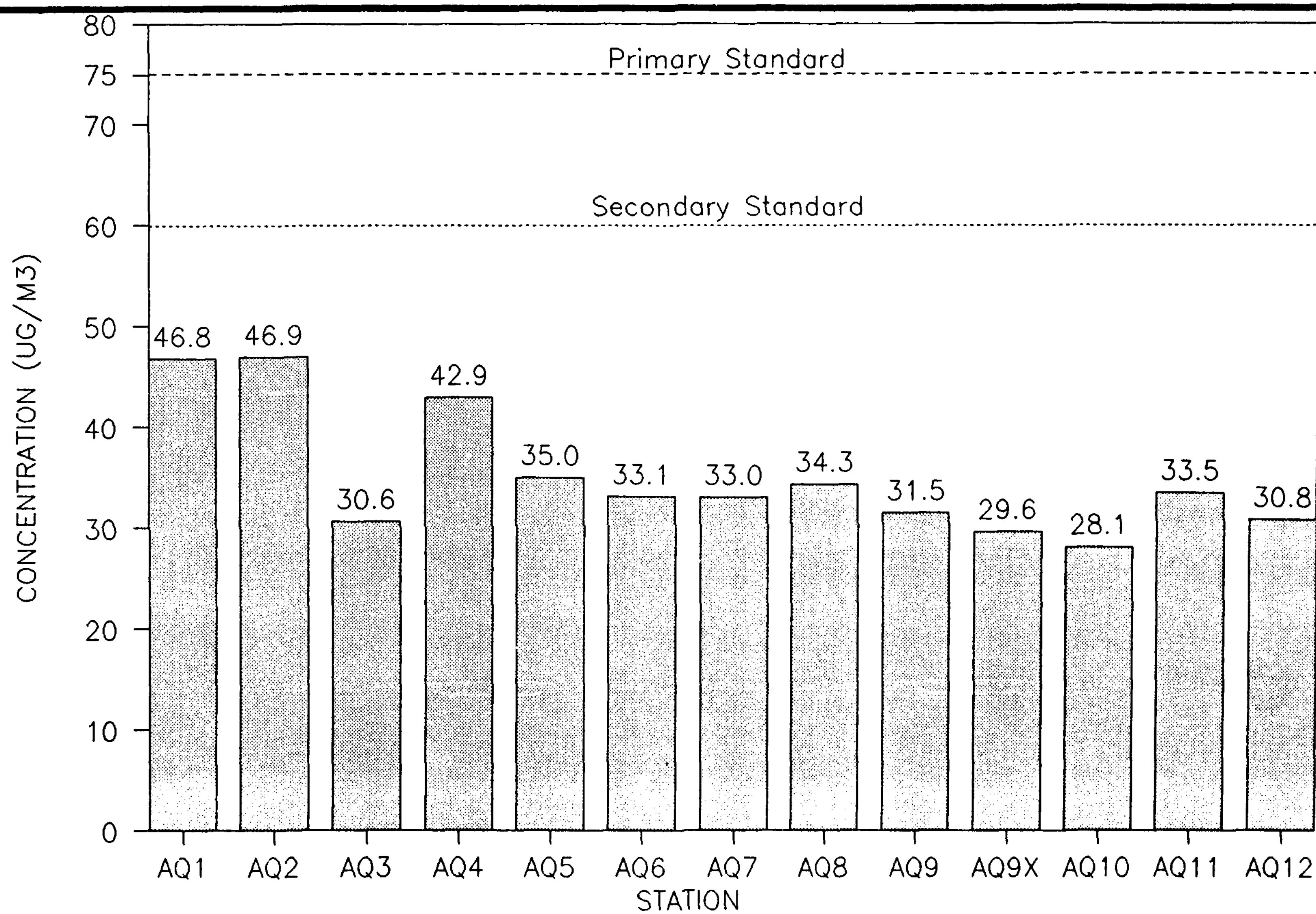
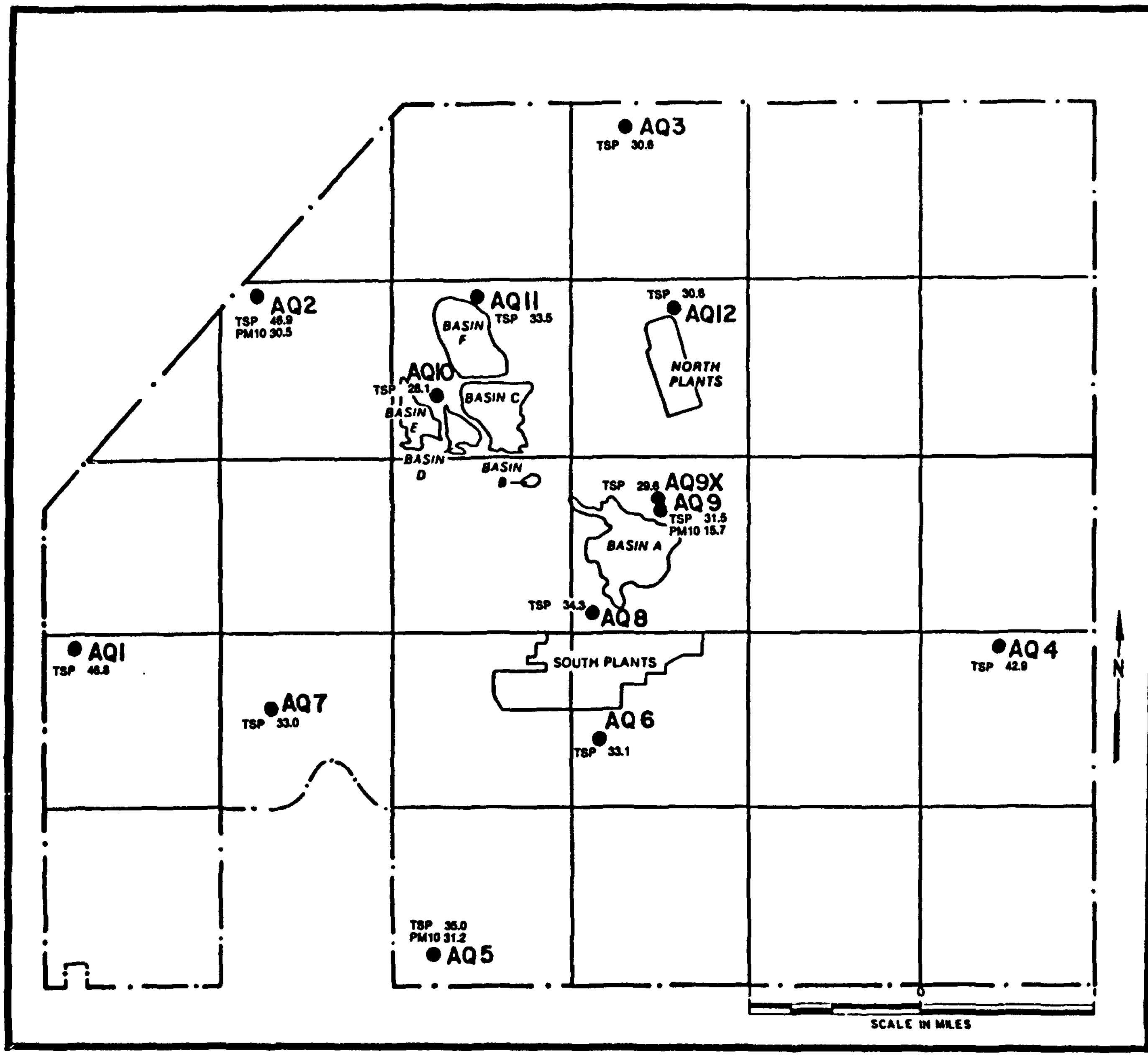


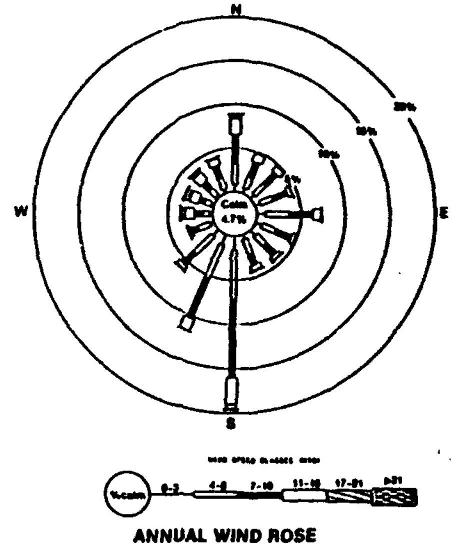

**Figure 4.1-1**

**TSP ANNUAL AVERAGE CONCENTRATION BY STATION**

SOURCE: ESE, 1988

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**




**EXPLANATION**

● Air Quality Monitoring Station

TSP Total Suspended Particulates

PM-10 Particulate Matter Less Than 10 Microns

Units - Micrograms Per Cubic Meter (ug/m3)

Figure 4.1-2

PARTICULATE MATTER ANNUAL AVERAGES

SOURCE: ESE, 1987

**Prepared for:**
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**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-[illegible]

boundaries. Higher concentrations of particulates were monitored during the winter.

The annual geometric mean values ranged from 28 ug/m$^3$ south of Basin F to 47 ug/m$^3$ at the West and Northwest Boundary. The lowest maximum 24-hour concentration was 47 ug/m$^3$, realized at the AQ4 on the East Boundary. The highest 24-hour value was 151 ug/m$^3$ at AQ6 south of South Plants. The monthly TSP concentrations were elevated in December at all of the monitoring stations. This coincides with sanding of roads during the winter months.

Only stations where 75 percent or more of yearly data are recovered can be considered valid indicators of ambient air quality for an area. Stations with less than 75 percent data recovery are indicated in Table 4.1-1. Reduced data collection was due to equipment and power failures. With the exception of AQ4, AQ5, AQ6, and AQ10, an average data recovery of 92 percent resulted from the remaining air quality stations, with an overall data recovery of 79 percent. The collocated samplers at AQ9 and AQ9x gave consistent results throughout the year.

4.1.1.2 <u>Particulate Matter 10 Microns or Less</u>

PM-10 was monitored at three air quality stations, two at the Arsenal boundary and one within the boundaries. Samples were collected on the same schedule as for TSP sampling. Figure 4.1-2 and Table 4.1-2 provide a summary of the PM-10 monitoring data from the year-long ambient air program at RMA. Appendices B and C contain the raw PM-10 data as well as data summaries. As with TSP concentrations, PM-10 levels were highest at the boundary stations and lowest at the interior of RMA.

The annual arithmetic mean values ranged from 16 ug/m$^3$ within the Arsenal boundary at AQ9 near Basin A to 31 ug/m$^3$ at the South Boundary at AQ5. Individual 24-hour values ranged from 5 to 94 ug/m$^3$, with lowest levels at the interior of RMA and higher levels at the boundary.

By using past TSP data, it is possible to predict which sites have a high probability of violating the PM-10 standard. When TSP levels from each site

Table 4.1-2 PM-10 Data Summary

| | | Concentration ($ug/m^3$) | |
|---|---|---|---|
| Station No. | Location | Annual Geometric Average* | Range of Individual 24-Hour Samples |
| AQ2 | Northwest Boundary | 30.5** | 6.4-93.5 |
| AQ5 | South Boundary | 31.2 | 13.0-89.9 |
| AQ9 | North of Basin A | 15.7** | 4.9-36.3 |

* Federal Standard: Annual - 50 $ug/m^3$
24-Hour - 150 $ug/m^3$

**Less than 75 percent data recovery due to equipment or power failure.

are compared to PM-10 levels, the concentration of PM-10 is approximately 66 percent of the TSP concentration. Figure 4.1-3 shows the correlation between TSP and PM-10 at AQ2 as a function of time at RMA.

#### 4.1.1.3 Asbestos

Ambient air samples were collected at four air quality stations and analyzed for asbestos fibers in order to detect airborne asbestos within the Arsenal boundary (AQ6, AQ8, and AQ12) and at the boundary (AQ1). Table 4.1-3 gives a summary of the asbestos monitoring data at RMA. As can be seen, no asbestos was found above the detection limit of 0.01 fiber/cubic centimeter of air (f/cc).

### 4.1.2 EVENT SAMPLING

As discussed previously, toxic airborne contaminants were sampled on an event basis according to established meteorological conditions which favored elevated concentrations of contaminants. VOCs, SVOCs, and metals were sampled near suspected contaminant sources during event conditions. The following sections summarize the monitoring results and Appendix B contains analytical data.

#### 4.1.2.1 VOC Sampling

Basin F was the primary suspected source of volatile organics. During low wind and warm conditions, the airborne concentrations of VOCs were anticipated to be the greatest near Basin F. Summaries of seven VOC sampling events, including concentrations of target compounds, identification of non-target compounds, and description of wind direction during the VOC sampling event, are presented in the following discussions.

In general, methylene chloride was detected in several samples. This compound is a common laboratory contaminant that is routinely detected in air, soil, water, and biological samples. Other compounds that were detected in the atmosphere near the basin correlate with contaminants found in Basin F. Some of the airborne contaminants are organic compounds that are naturally associated with vegetation found at RMA.

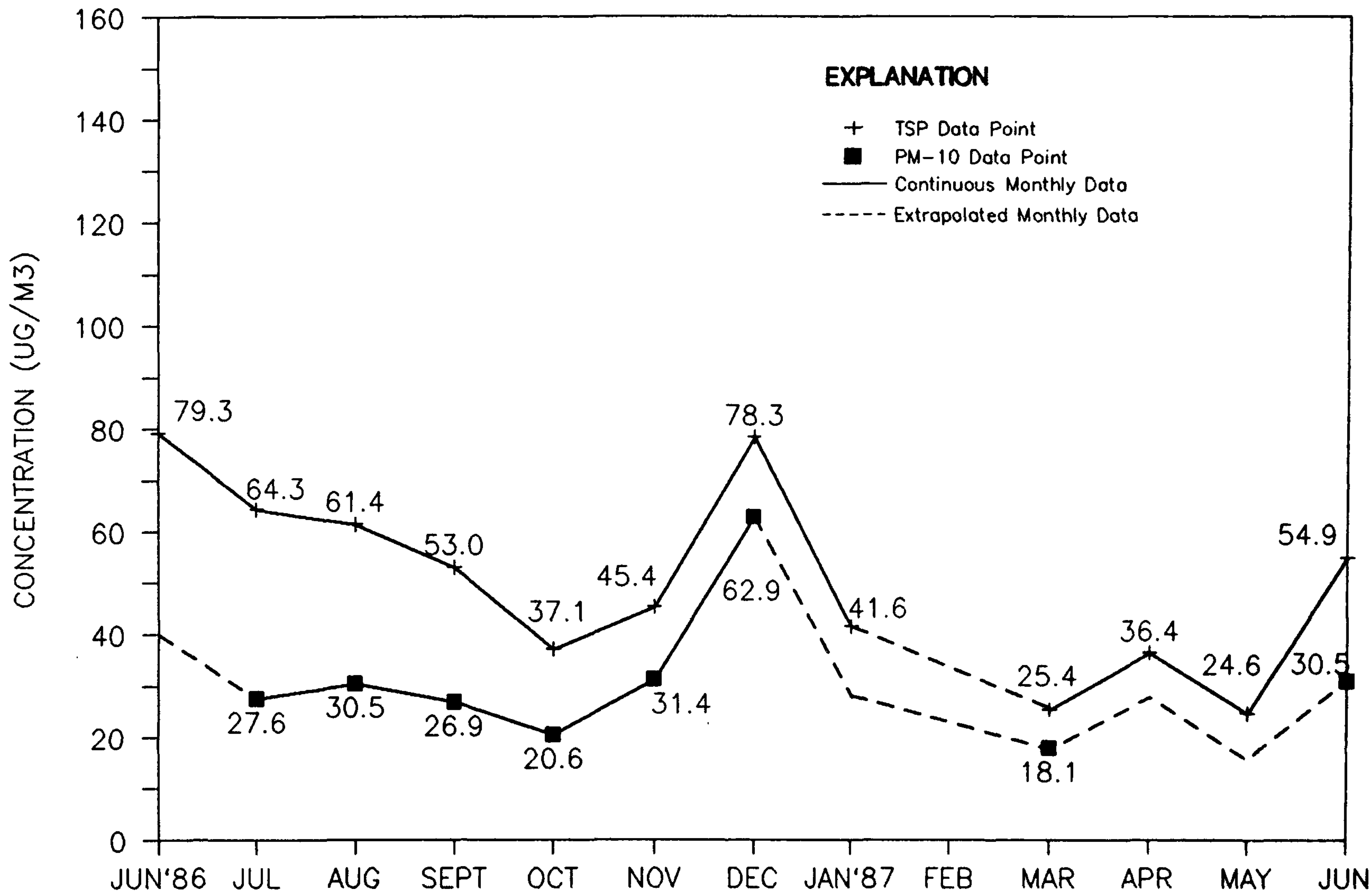


**Figure 4. 1-3**

**TYPICAL TSP VS PM-10 MONTHLY AVERAGES FOR STATION AQ2**

SOURCE: ESE, 1988

**Prepared for:**
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Table 4.1-3. Asbestos Data Summary.

| Station No. | Location | Concentration (fibers/cc) Annual Average | Range of Individual 8-hour Samples* |
|---|---|---|---|
| AQ1 | West Boundary | <0.01 | <0.01 |
| AQ6 | South of South Plants | <0.01 | <0.01 |
| AQ8 | South of Basin A | <0.01 | <0.01 |
| AQ12 | North of North Plants | <0.01 | <0.01 |

* OSHA 8-hour Standard: 0.2 fibers/cc
CDH Guideline for Building Indoor Air: 0.01 fibers/cc

Source: ESE, 1988.

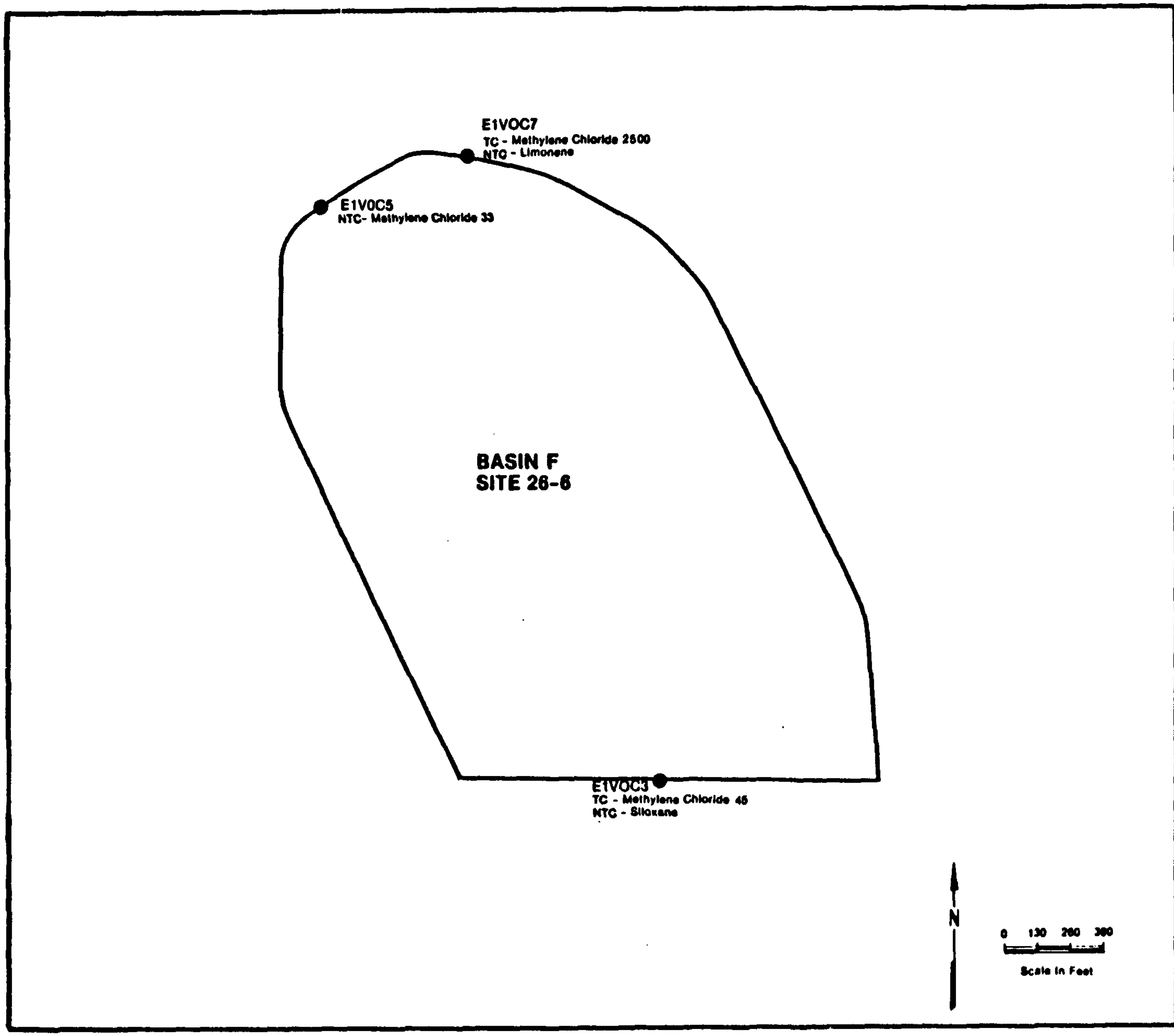
Event 1 - Figure 4.1-4 shows the results of VOC sampling on November 28, 1985. Winds were from the south-southeast at approximately 4 mph during sampling. Methylene chloride was the only target compound and it was detected in all three samples at concentrations from 33 to 2500 ug/$m^3$. Methylene chloride is not prevalent in Basin F materials and is a suspected laboratory contaminant. No other target compounds were detected.

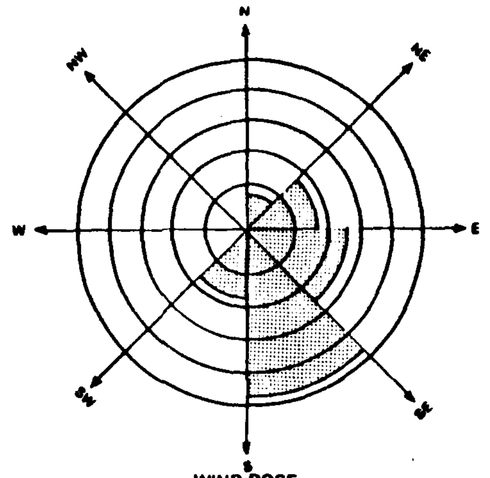
Siloxane and limonene were nontarget compounds that were identified in samples. Siloxane is an organic inherent to GC columns and is commonly known as "Column Bleed". Limonene is a solvent used in manufacturing resins. It is also naturally produced in the environment and is associated with turpentines.

Event 2 - Figure 4.1-5 shows the results of VOC sampling on June 10, 1987. Winds were from the east-southeast at approximately 4 mph during sampling. No target compounds were detected at four of the six stations around the basin. Target compounds were detected in two samples, chloroform at 30 ug/$m^3$ and methylene chloride at 74 ug/$m^3$. Chloroform is a common solvent, and is probably not a laboratory artifact.

Nontarget compounds were identified in all six samples and included: siloxane, 3-methylheptane, 1-pentane, trichlorofluoromethane, acetamide, and isodecene. Isodecene, 3-methylheptane and 1-pentane, are common organics found in gasoline. Trichlorofluoromethane is a refrigerant and aerosol spray propellant. Acetamide is an organic solvent used in the manufacturing of explosives.

Event 3 - Figure 4.1-6 shows the results of VOC sampling on June 22, 1987. Winds were from the north-northwest at approximately 11 mph during sampling. No target compounds were found in any of the eight samples collected. Only four samples contained nontarget compounds. Those compounds included: acetone, siloxane, 1-ethyl-2-heptylcyclopropane, n-butyl-1-1-butanamine, 2-beta-pinene, limonene, 2,5,6-trimethyloctane, and 2,6-bis-1,1-dimethylethyl-2,5-cyclohexadiene-1,4-dione. Acetone is a common industrial solvent and may be a laboratory artifact. N-butyl-1-butanamine is also known as di-n-butylamine. The compound 2-beta-pinene is a pine oil derivative and may be




MET STATION: RMA 2 WIND ROSE SCALE: 0-40%

**EXPLANATION**

● E1VOC3 Sampling Location, and Event (E1) and *Sample Number (VOC3)*

TC - Target Compound

NTC - Non-Target Compound

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 11/28/86 (1243-1550)

Wind Speed - 1.42 mph

Temperature - 65.8°F

Figure 4.1-4

VOC - EVENT 1

SOURCE: ESE, 1987

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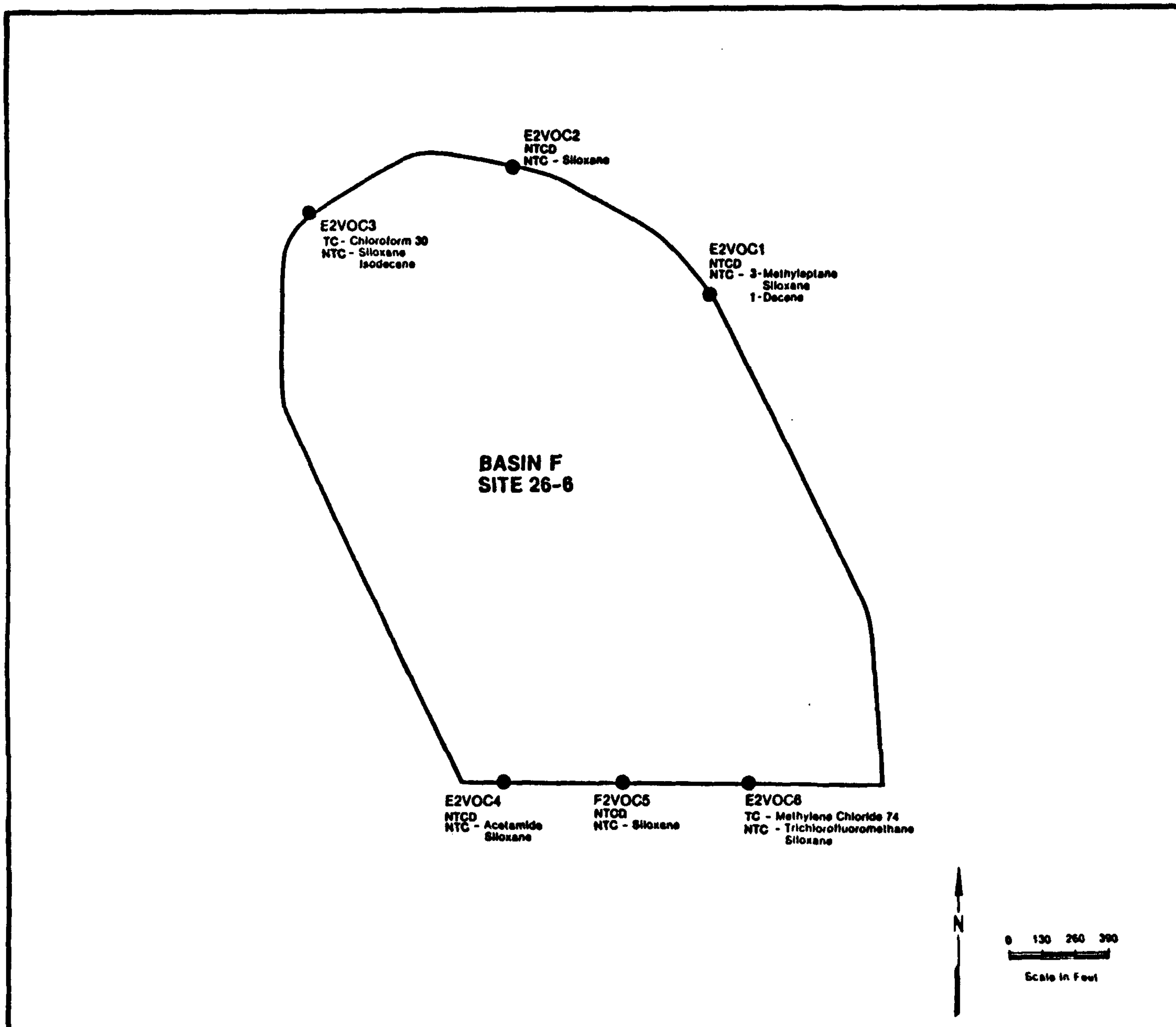
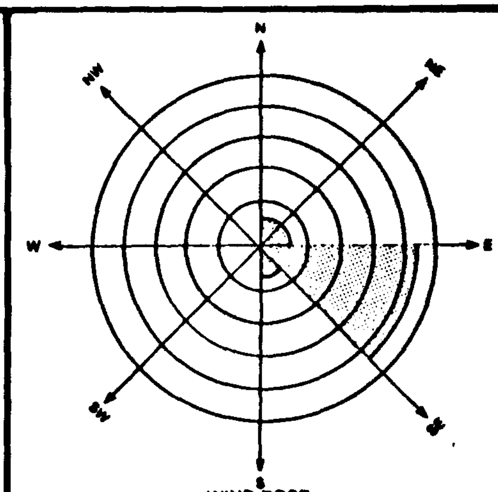
T18D-AR-010




MET STATION: RMA 1 WIND ROSE SCALE: 0-70%

EXPLANATION

● E2VOC6 Sampling Location, and Event (E2) and Sample Number (VOC6).

TC - Target Compound

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 6/10/87 (1450-1640)

Wind Speed - 3.6 mph

Temperature - 78.5°F

Figure 4.1-5

VOC - EVENT 2

SOURCE: ESE, 1987

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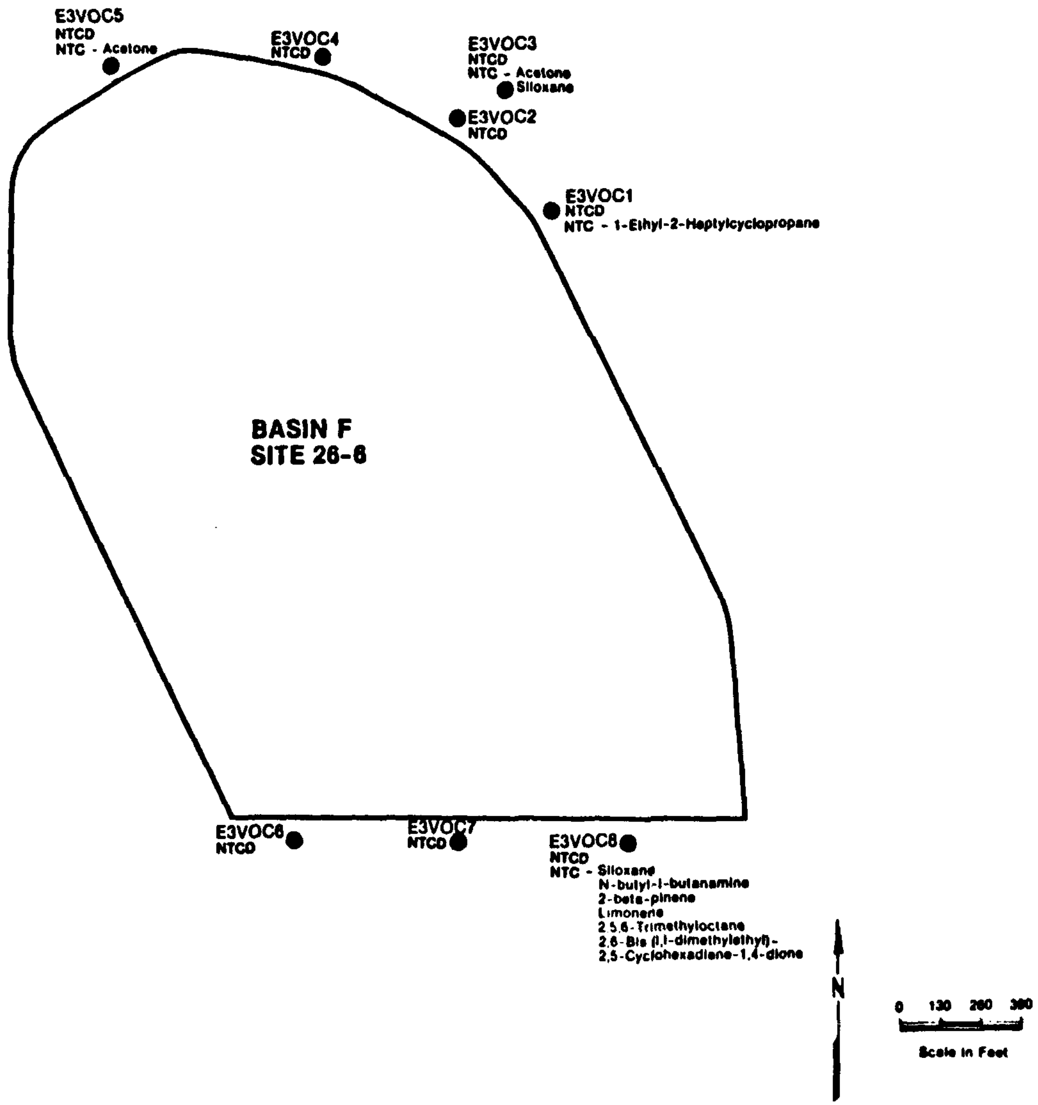


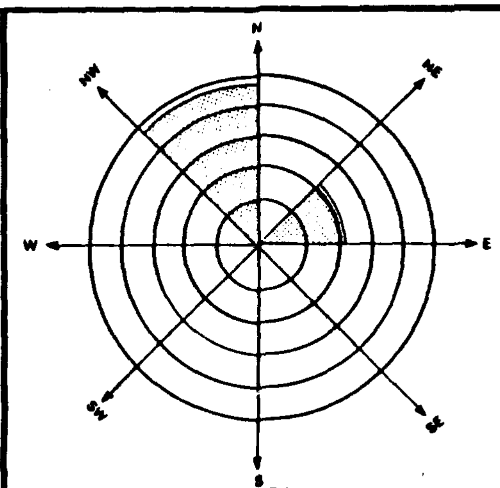


MET STATION: RMA 2 WIND ROSE SCALE: 0-40%

**EXPLANATION**

● E3VOC8 Sampling Location, and Event (E3) and Sample Number (VOC8).

TC - Target Compound

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 8/22/87 (1453-1708)

Wind Speed and Temperature Did Not Record

Figure 4.1-6

VOC - EVENT 3

SOURCE: ESE, 1987

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Aberdeen Proving Ground, Maryland

T18D-AR-012

naturally occuring. The compound 2,5,6-trimethyloctane is a product ingasoline and solvents. The origin of the final compound is not known.

Event 4 - Figure 4.1-7 shows the results of VOC sampling on July 2, 1987. Winds were from the east-southeast at approximately 4 mph during sampling. Target compounds were not found in any of the five samples.

In two of the samples nontarget compounds were identified including siloxane and acetone.

Event 5 - Figure 4.1-8 shows the results of VOC sampling on July 10, 1987. Winds were variable from the northeast to west and southeast to east at approximately 5 mph. Methylene chloride was detected in two of the eight samples at 23 and 38 $ug/m^3$. No other target compounds were detected.

Nontarget compounds were identified in seven of the eight samples. The compounds included: siloxane, acetone, and trichlorofluoromethane.

Event 6 - Figure 4.1-9 shows the results of VOC sampling on July 24, 1987. Winds were from the north at approximately 3 mph. Target compounds were not detected in any of eight samples.

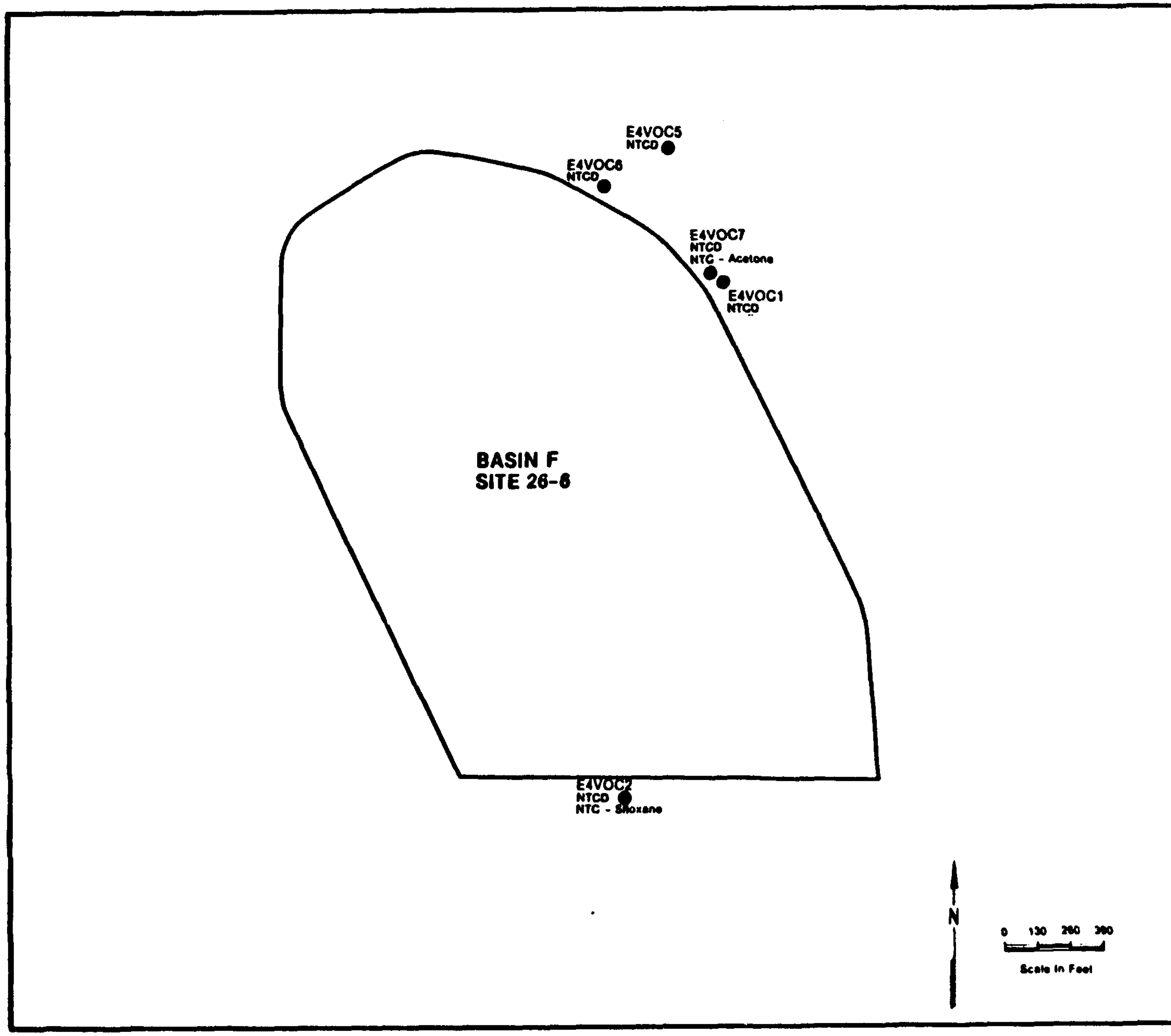
Nontarget compounds were found in all eight samples and included: siloxane, 2-butanone, and acetone. The compound 2-butanone is a common solvent which is also known as methyl ethyl ketone.

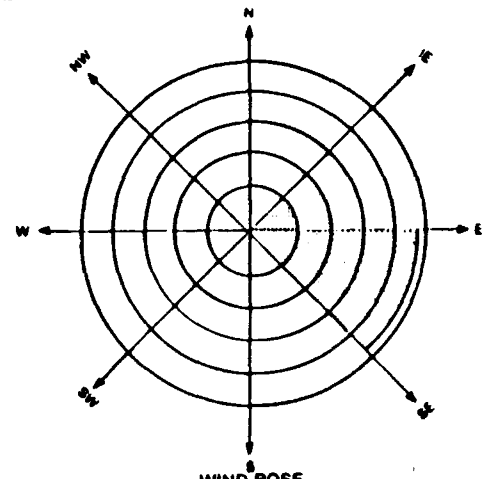
Event 7 - Figure 4.1-10 shows the results of VOC sampling on August 5, 1987. Winds were variable from the west at approximately 3 mph. Methylene chloride was the only target compound detected. It was observed in four of nine samples at concentrations ranging from 22 to 70 $ug/m^3$.

Nontarget compounds were identified at seven of eight stations. The compounds included: siloxane, trichlorofluoromethane, and acetone.

#### 4.1.2.2 SVOC Sampling

Semivolatile organics were sampled during five events which favored elevated airborne concentrations of SVOCs. Moderate wind speeds during warm, dry




MET STATION: RMA 3 WIND ROSE SCALE: 0-80%

**EXPLANATION**

● E4VOC2 Sampling Location, and Event (E4) and Sample Number (VOC2)

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 7/2/87 (1308 - 1505)

Wind Speed - 3.9 mph

Temperature - 79.5°F

Figure 4.1-7

VOC - EVENT 4

SOURCE: ESE, 1987

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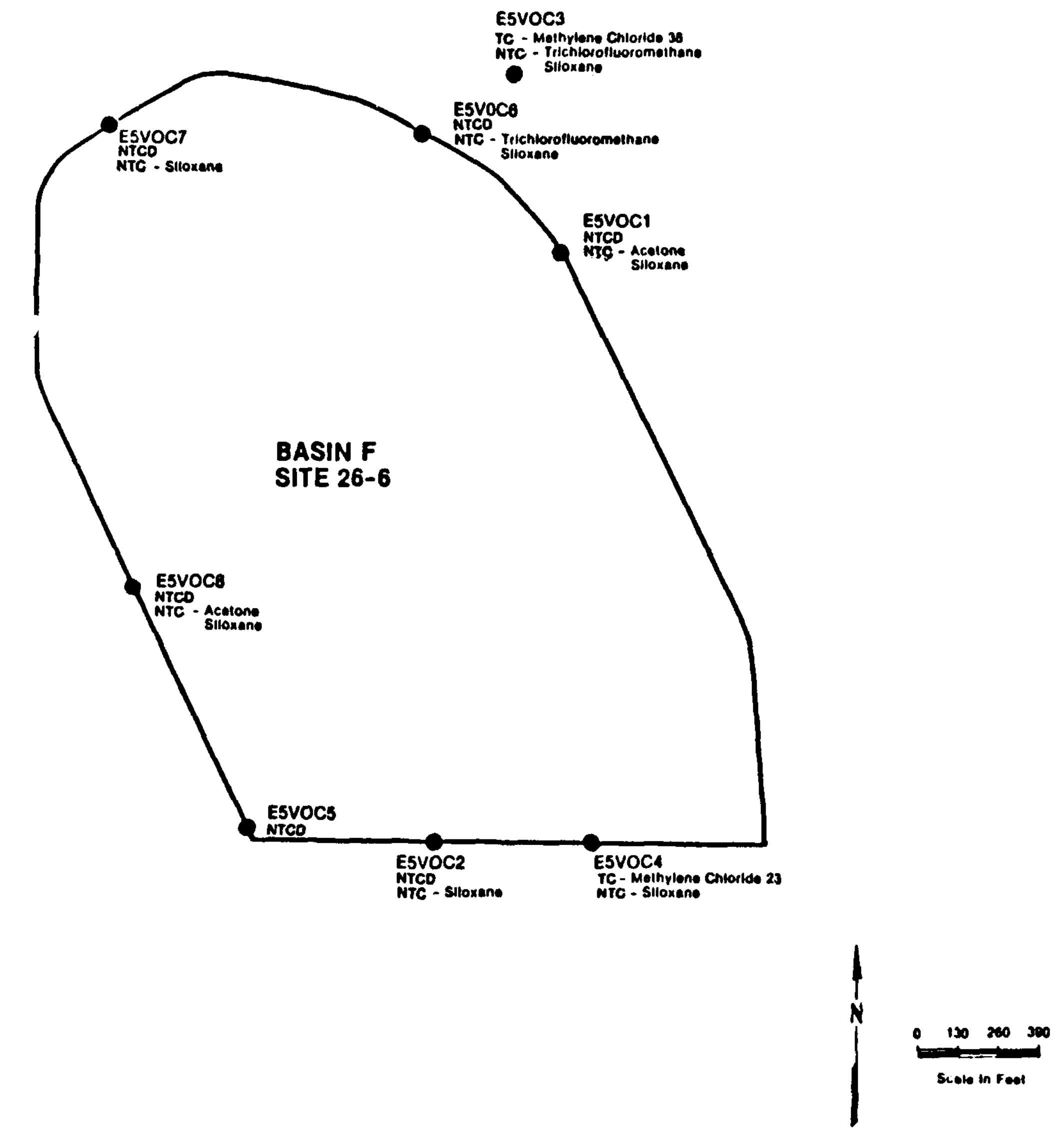


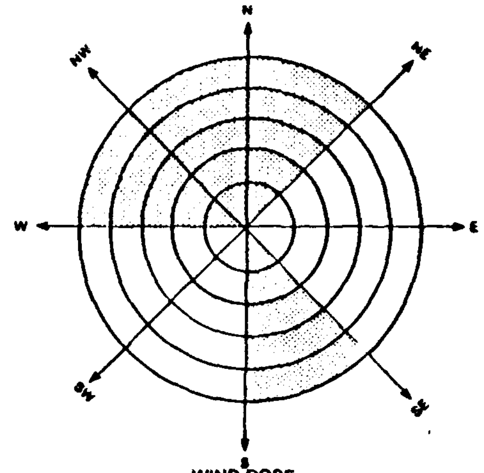


MET STATION: RMA 1 WIND ROSE SCALE: 0-25%

EXPLANATION

● E5VOC4 Sampling Location, and Event (E5) and Sample Number (VOC4).

TC - Target Compound

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 7/10/87 (1430-1630)

Wind Speed - 5.4 mph

Temperature - 87.5 °F (RMA Met 2)

Figure 4.1-8

VOC - EVENT 5

SOURCE: ESE, 1987

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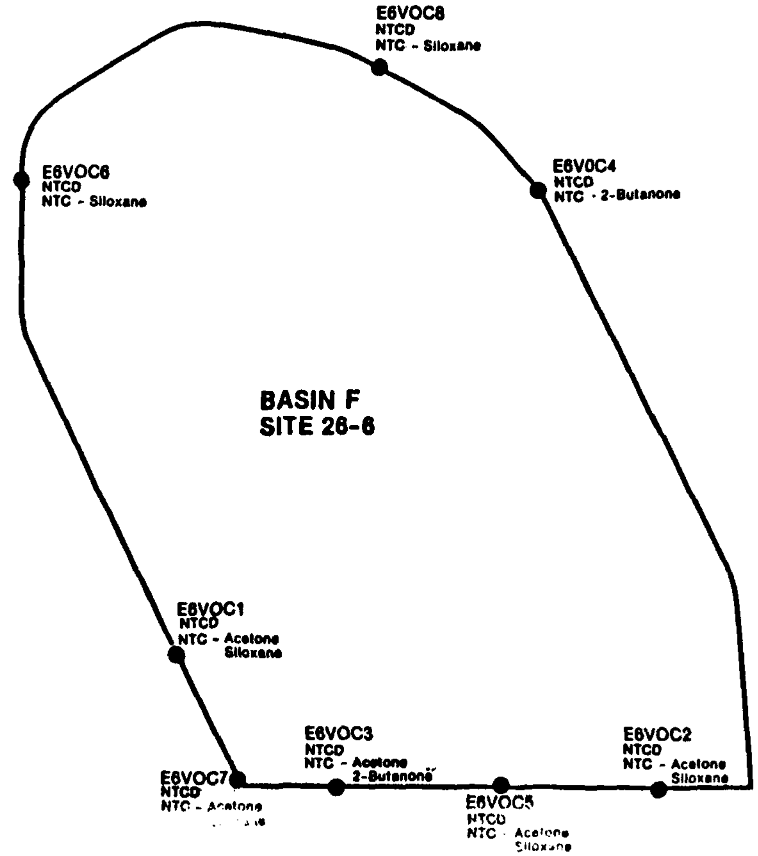


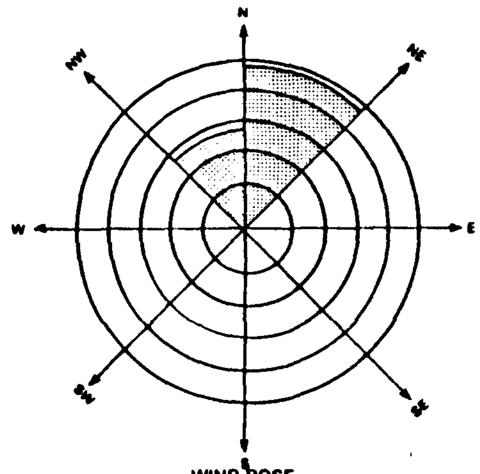


WIND ROSE

MET STATION: RMA 1 SCALE: 0-65%

EXPLANATION

● E6VOC2 Sampling Location, and Event (E6) and Sample Number (VOC2).

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 7/24/87 (1200-1400)

Wind Speed - 2.9 mph

Temperature - 83.4°F

Figure 4.1-9

VOC - EVENT 6

SOURCE: ESE, 1987

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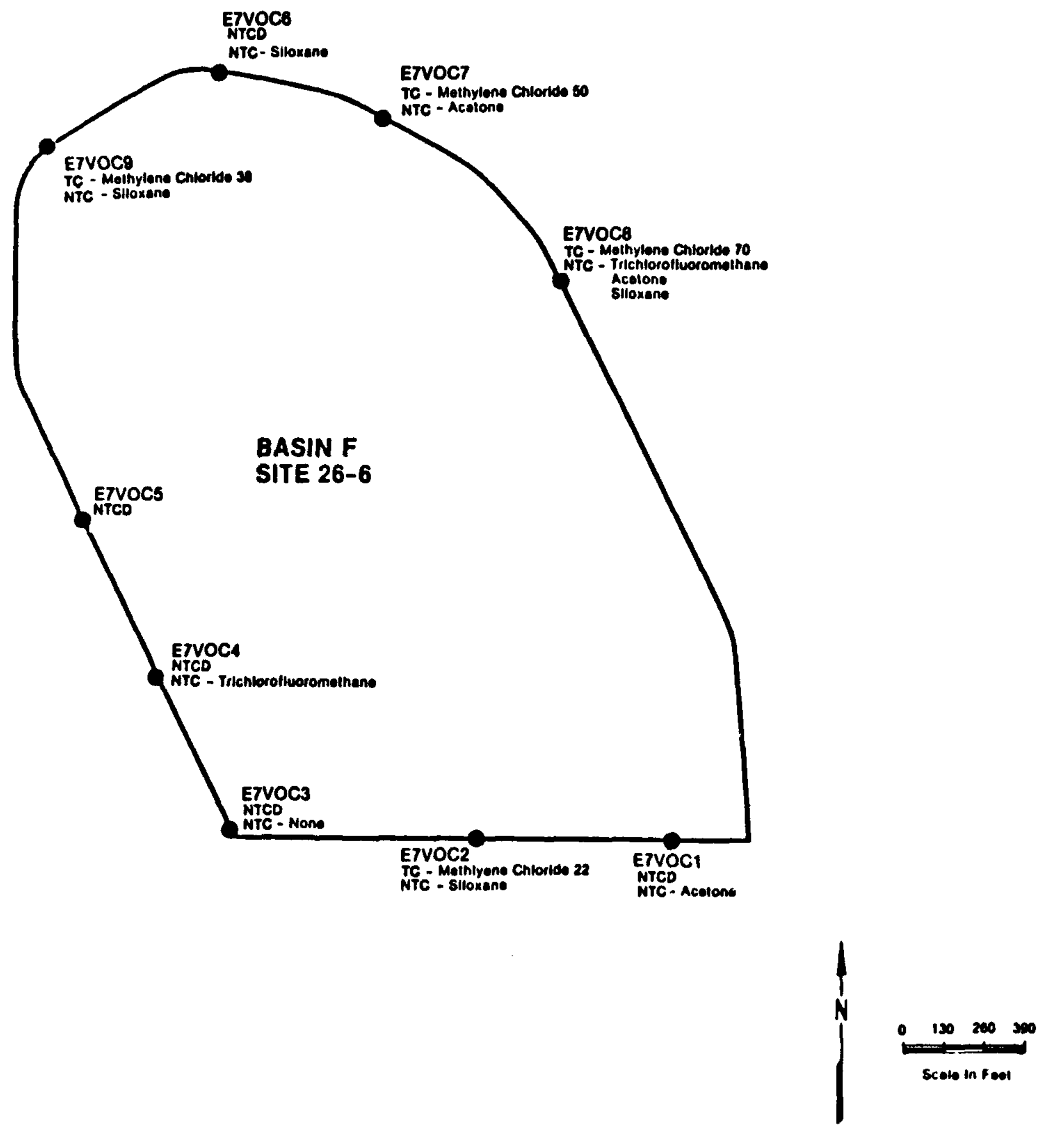


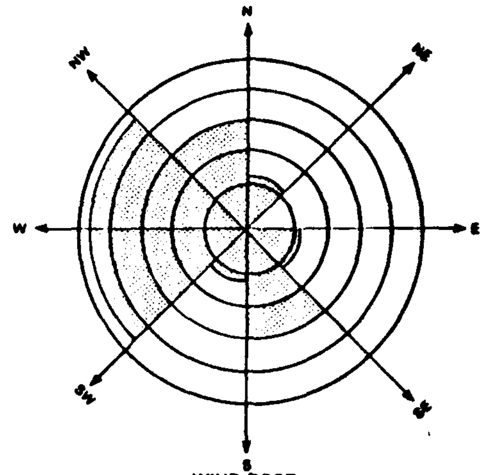


MET STATION: RMA 1 WIND ROSE SCALE: 0-25%

EXPLANATION

● E7VOC1 Sampling Location, and Event (E7) and Sample Number (VOC1).

TC - Target Compound

NTC - Non-Target Compound

NTCD - No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 8/5/87 (1325-1620)

Wind Speed - 3.4 mph

Temperature - 88.8°F

Figure 4.1-10

VOC - EVENT 7

SOURCE: ESE, 1987

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conditions were anticipated to favor collection of SVOCs. Basins A and F were suspected of being the sites with the greatest potential for emitting SVOCs. Three sampling events were conducted at Basin A and two were conducted at Basin F.

In general, there were minimal detections of target SVOCs around Basin A. SVOCs were detected around Basin F and included: aldrin, dieldrin, endrin, and isodrin. There were numerous, nontarget SVOCs identified near Basin F. The following discussions describe and explain the results of the SVOC sampling events and list the nontarget compounds that were identified for each event.

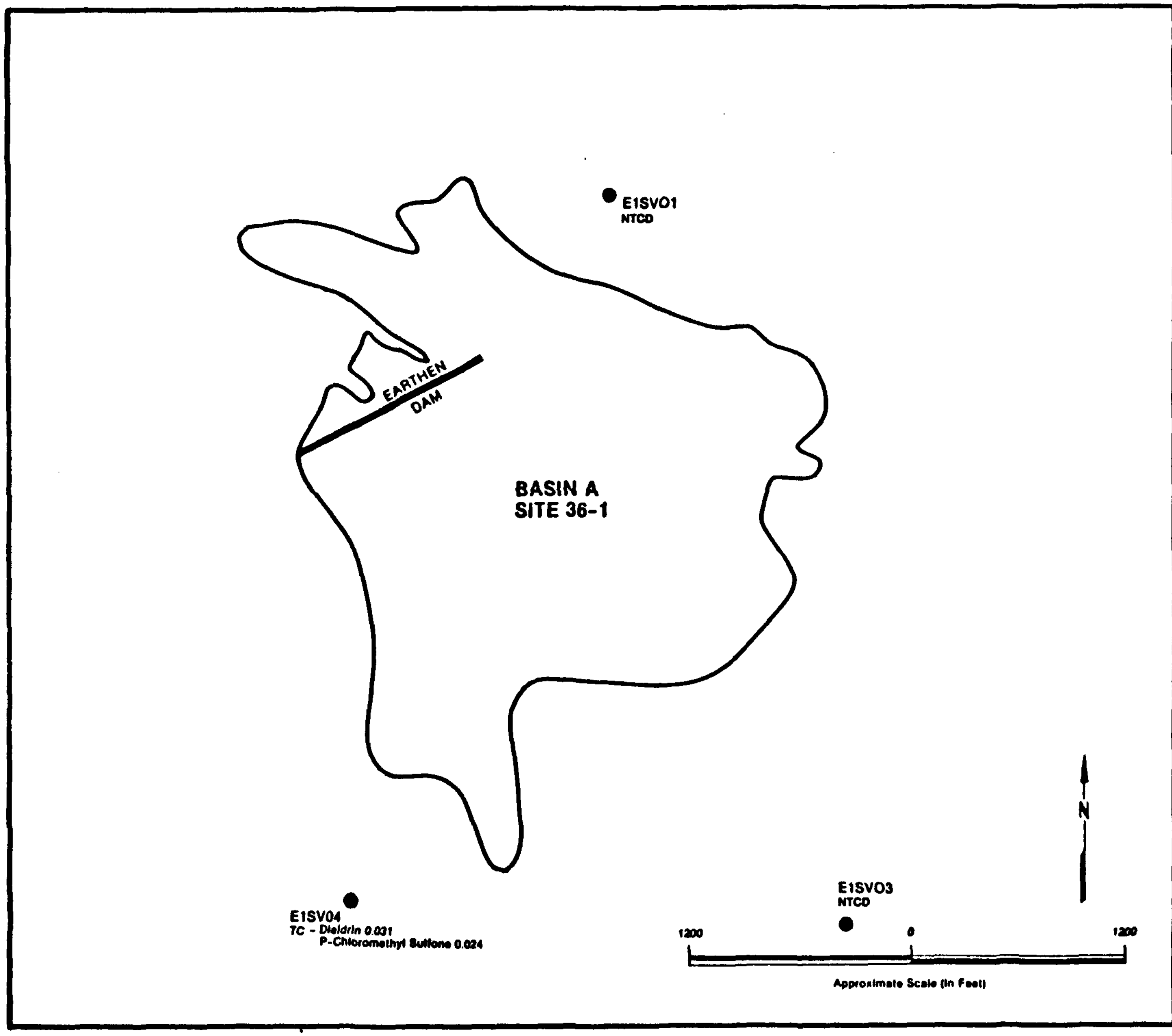
Event 1 - Figure 4.1-11 and Table 4.1-4 summarize the SVOC sampling event on May 13, 1987 at Basin A. The winds were from the south-southwest at approximately 4 mph. Target compounds were detected in one of three samples, and included dieldrin at 0.031 ug/m$^3$ and $CPMSO_2$ at 0.024 ug/m$^3$. These are common contaminants at RMA.

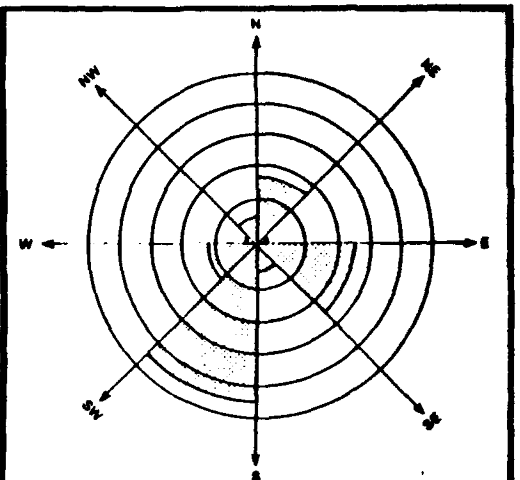
Nontarget SVOCs were identified in all three samples and are listed in Table 4.1-4. Most of these are background polynuclear aromatic hydrocarbons found in urban areas. They are associated with gasoline and vegetation.

Event 2 - Figure 4.1-12 and Table 4.1-5 summarize the SVOC sampling event on May 15, 1987 at Basin A. The winds were from the south-southeast at approximately 7 mph. One sample was analyzed and no target compounds were detected.

Nontarget SVOCs were identified at this station and are shown in Table 4.1-5. Dioctyladipate is a plasticizer as well as a possible laboratory contaminant.

Event 3 - Figure 4.1-13 and Table 4.1-6 summarize the SVOC sampling event on May 19, 1987 at Basin A. Winds were variable from the south at 3 mph. Four samples were collected and no target compounds were detected.




WIND ROSE

MET STATION: RMA 1 SCALE: 0-40%

**EXPLANATION**

● E1SVO3 - Sampling Location, and Event (E1) and Sample Number (SVO3).

TC-Target Compound

NTCD-No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 8/13/87

Wind Speed - 4.0 mph

Temperature - 73.8°F

Figure 4.1-11

SVOC - EVENT 1

SOURCE: ESE, 1987

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Table 4.1-4. Event 1 - Nontarget SVOCs.

E1SVO*1

Phenanthrene
Trimethylpentadecanone
Eicosane
Tetramethylheptadecane

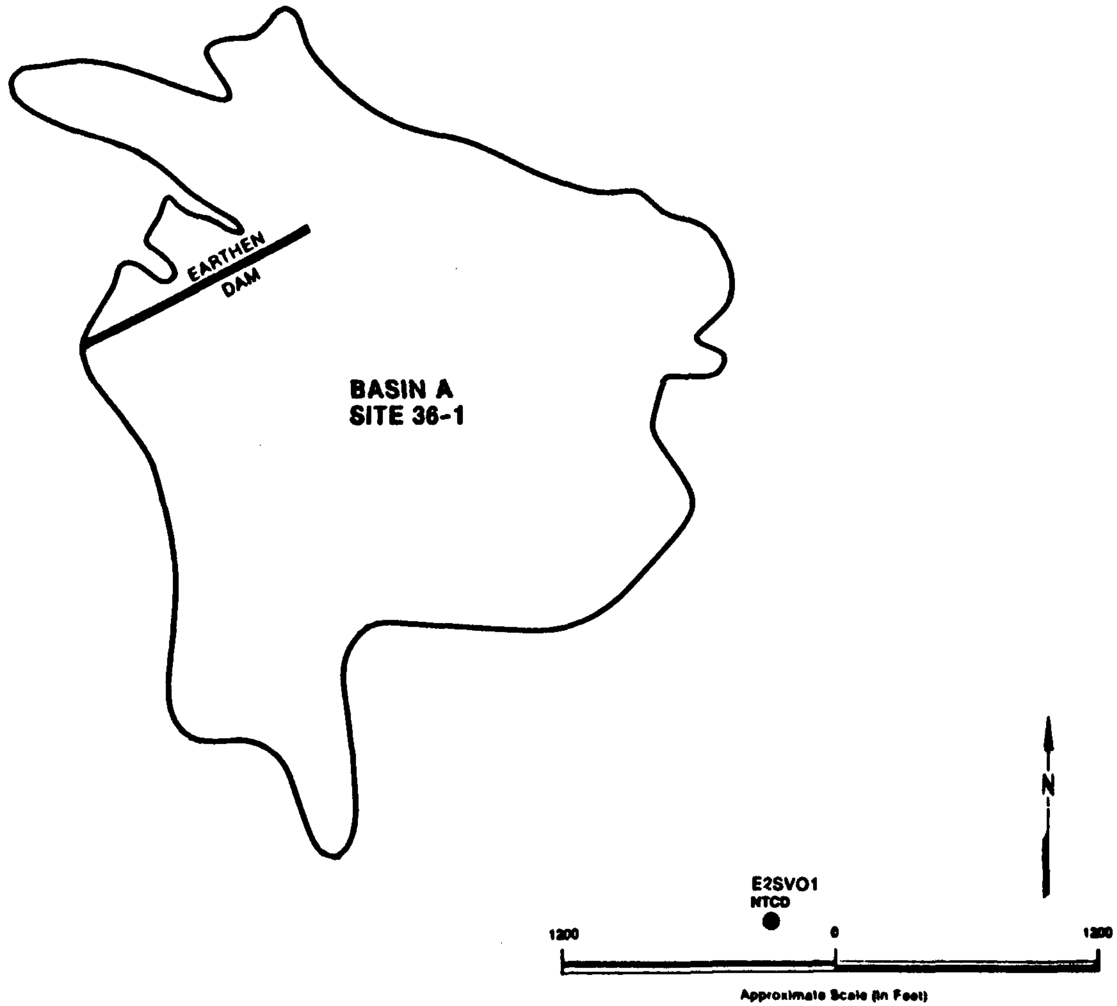
E1SVO*3

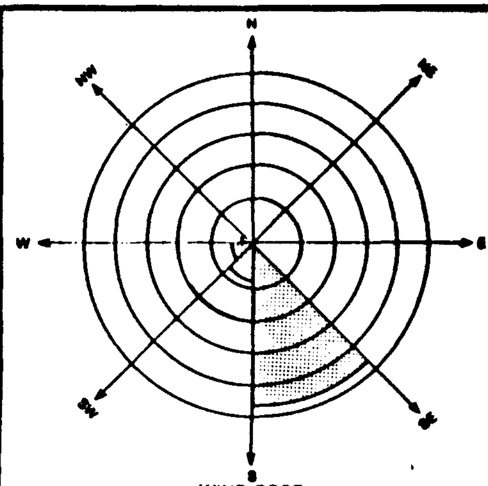
Benzoic acid
Nonanoic acid
Trimethylpentadecanone
Nonadecane
Eicosane
Tetramethylheptadecane

E1SVO*4

Benzoic acid
Methyldodecanoate
Methyltetradecanoate
Phenanthrene
Methylhexadecanoate

Source: ESE, 1988.




WIND ROSE

MET STATION: RMA 1 SCALE: 0-75%

EXPLANATION

● E2SVO1 - Sampling Location, and Event (E2) and Sample Number (SVO1).

NTCD-No Target Compound Detected

Units-Micrograms Per Cubic Meter (ug/m3)

Sampling Event-5/15/87

Wind Speed - 6.8 mph

Temperature - 77.8 °F

Figure 4.1-12

SVOC - EVENT 2

SOURCE: ESE, 1987

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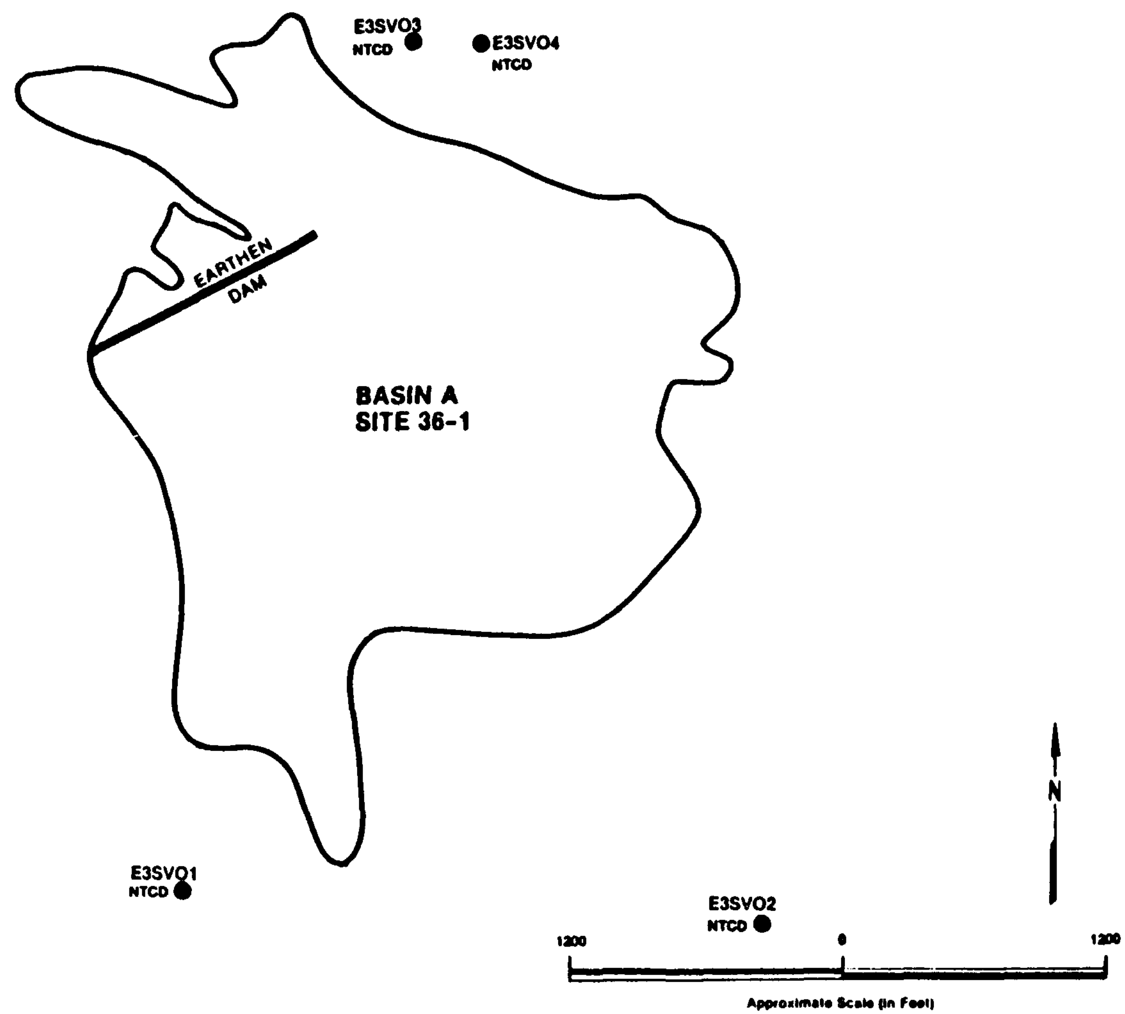
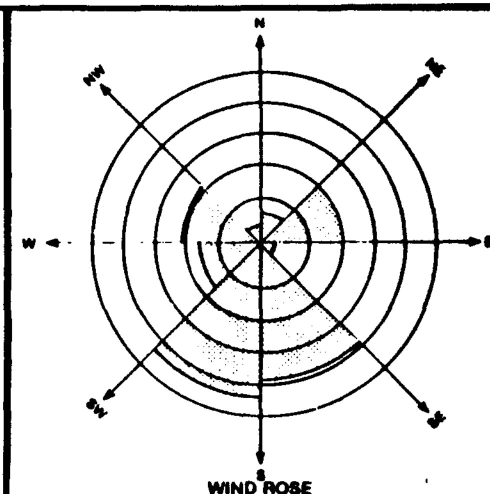
Table 4.1-5. Event 2 - Nontarget SVOCs.

| |
|---|
| E2SVO*1 |
| Dioctyladipate |
| Aliphatic hydrocarbon |

Source: ESE, 1988.




MET STATION: RMA 1 SCALE: 0-30%

EXPLANATION

● E3SVO2 - Sampling Location, and Event (E3) and Sample Number (SVO2).

NTCD-No Target Compound Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 8/19/87

Wind Speed - 4.3 mph

Temperature - 67.1°F

Figure 4.1-13

SVOC - EVENT 3

SOURCE: ESE, 1987

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Table 4.1-6. Event 3 - Nontarget SVOCs.

---

E3SVO*1

Benzoic acid
Possibly - $C_{10}H_{10}N_2O$
Trimethylpentadecanone
Nonadecane
Hexadecanoic acid
Eicosane

E3SVO*2

Acetophenone
Phenanthrene
Tetramethylhexadecane
Analiphatic hydrocarbon
Analiphatic hydrocarbon (probably) ($C_{21}H_{44}$)

E3SVO*3

Benzoic acid
(possibly) $C_{10}H_{10}N_2O$
Methyltetradecanoate
Trimethylpentadecanone
Methylhexadecanoate

E3SVO*4

Benzoic acid
(possibly) $C_{10}H_{10}N_2O$
Trimethylpentadecanone
Nonadecane
Hexadecanoic acid
Eicosane

---

Source: ESE, 1988.

Table 4.1-6 shows the nontarget SVOCs that were identified. Many of these are background hydrocarbons related to plant materials.

Event 4 - Sampling and analyses errors. Data was invalid.

Event 5 - Figure 4.1-14 and Table 4.1-7 summarize the SVOC sampling event on June 12, 1987 at Basin F. The winds were from the south at approximately 5 mph. Target SVOCs were detected at all four stations. The contaminants included: dieldrin, 0.051 to 0.2 ug/$m^3$; endrin, 0.071 to 0.13 ug/$m^3$; aldrin, 0.067 to 0.20 ug/$m^3$; isodrin, 0.038 ug/$m^3$; CPMSO, 0.047 to 0.065 ug/$m^3$; and $CPMSO_2$, 0.34 to 0.37 ug/$m^3$. These compounds are common RMA contaminants.

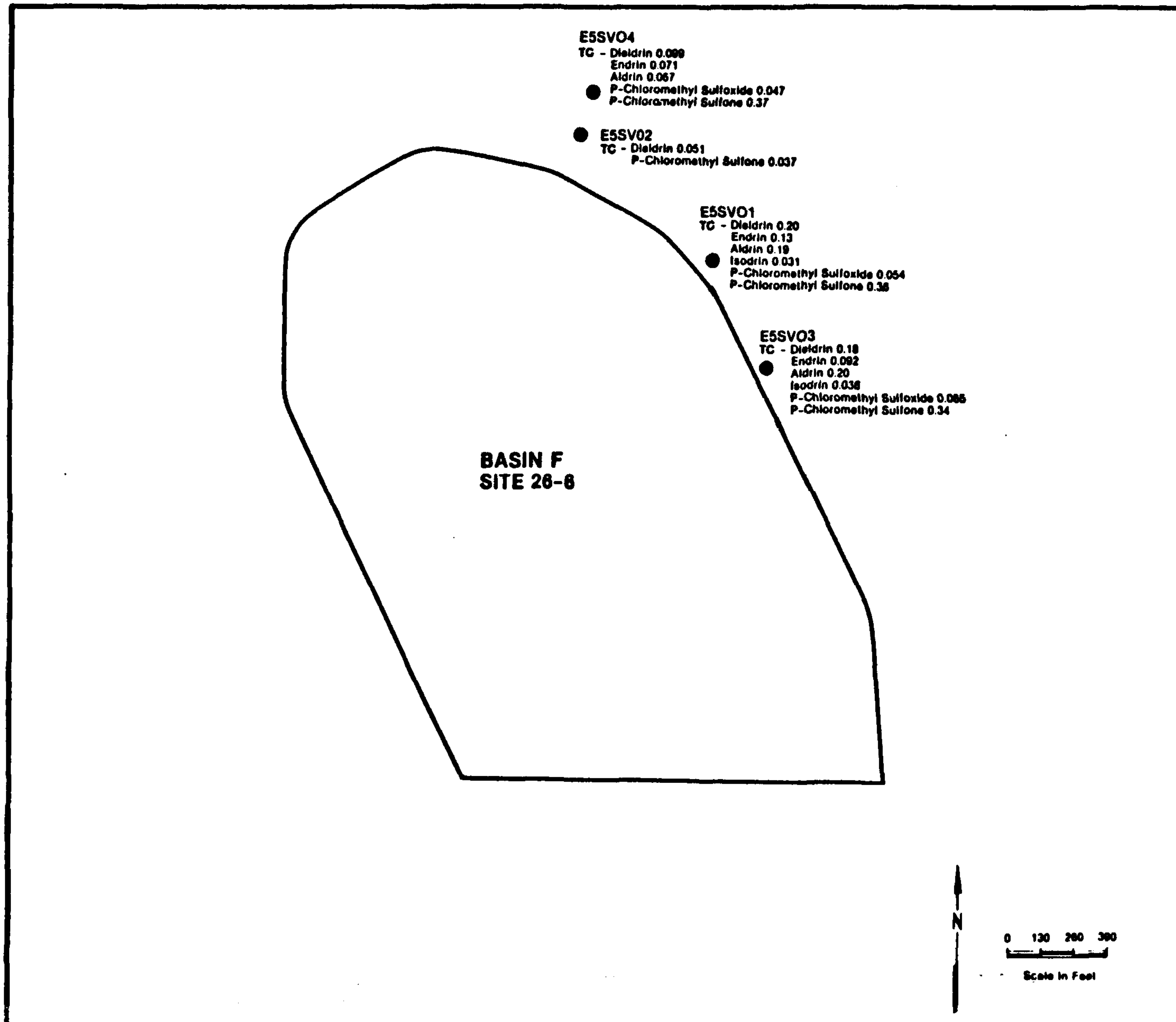
Table 4.1-7 summarizes the nontarget SVOCs at all four stations. Most of these compounds are background hydrocarbons related to plant materials or are derivatives from pesticides.

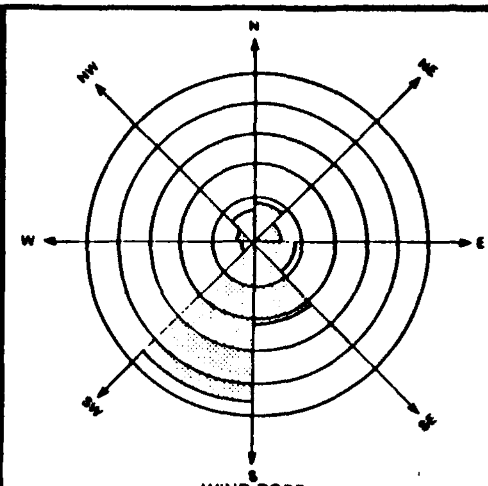
Event 6 - Figure 4.1-15 and Table 4.1-8 summarize the SVOC sampling event on June 18, 1987 at Basin F. Winds were from the southeast at 4 mph. The following target SVOCs were detected at the four sampling stations: dieldrin, 0.041 to 1.6 ug/$m^3$; endrin, 0.031 to 0.13 ug/$m^3$; aldrin, 0.064 to 0.087 ug/$m^3$; CPMSO, 0.026 to 0.039 ug/$m^3$; and $CPMSO_2$, 0.56 to 1.7 ug/$m^3$.

Table 4.1-8 contains a list of the nontarget SVOCs identified at Basin F. Again these are common background organics or derivatives from organics.

4.1.2.3 Metals Samples

Samples were collected for metals analysis during dry, windy periods near the basins and at the boundaries. There were 16 sampling events with one to eight samples collected per event. The samples were analyzed for arsenic, cadmium, chromium, copper, mercury, lead, and zinc. Figures 4.1-16 through 4.1-31 summarize the results of each event and Table 4.1-9 summarizes all of the data that was collected and analyzed for metals.




MET STATION: RMA 1 WIND ROSE SCALE: 0-45%

**EXPLANATION**

● E5SVO3 - Sampling Location, and Event (E5) and Sample Number (SVO3).

TC - Target Compound

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 8/12/87

Wind Speed - 3.7 mph

Temperature - 70.9°F

Figure 4.1-14

SVOC - EVENT 5

SOURCE: ESE, 1987

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Table 4.1-7. Event 5 - Nontarget SVOCs.

---

E5SVO*1

3-phenyl 2-propenoic acid ethyl ester
1,2,3,4,7,7 - hexachloro bicyclo [2,2,1] hepta-2,5-diene
1,2,3,4,5,7,7 - heptachloro bicyclo [2,2,1] hept-2-ene
Tetrachlorobenzene
Nonadecane
Eicosane
2,6,10,15-Tetramethylheptadecane
oil ($C_{16}$ to $C_{28}$ hydrocarbons)

E5SVO*2

Benzothiazole
$C_{18}$ to $C_{20}$ hydrocarbon
Nonadecane
Eicosane
2,6,10,15-Tetramethylheptadecane
Docosane
$C_{23}H_{48}$
Butylbenzylphthalate
oil ($C_{16}$ to $C_{28}$ hydrocarbons)

E5SVO*3

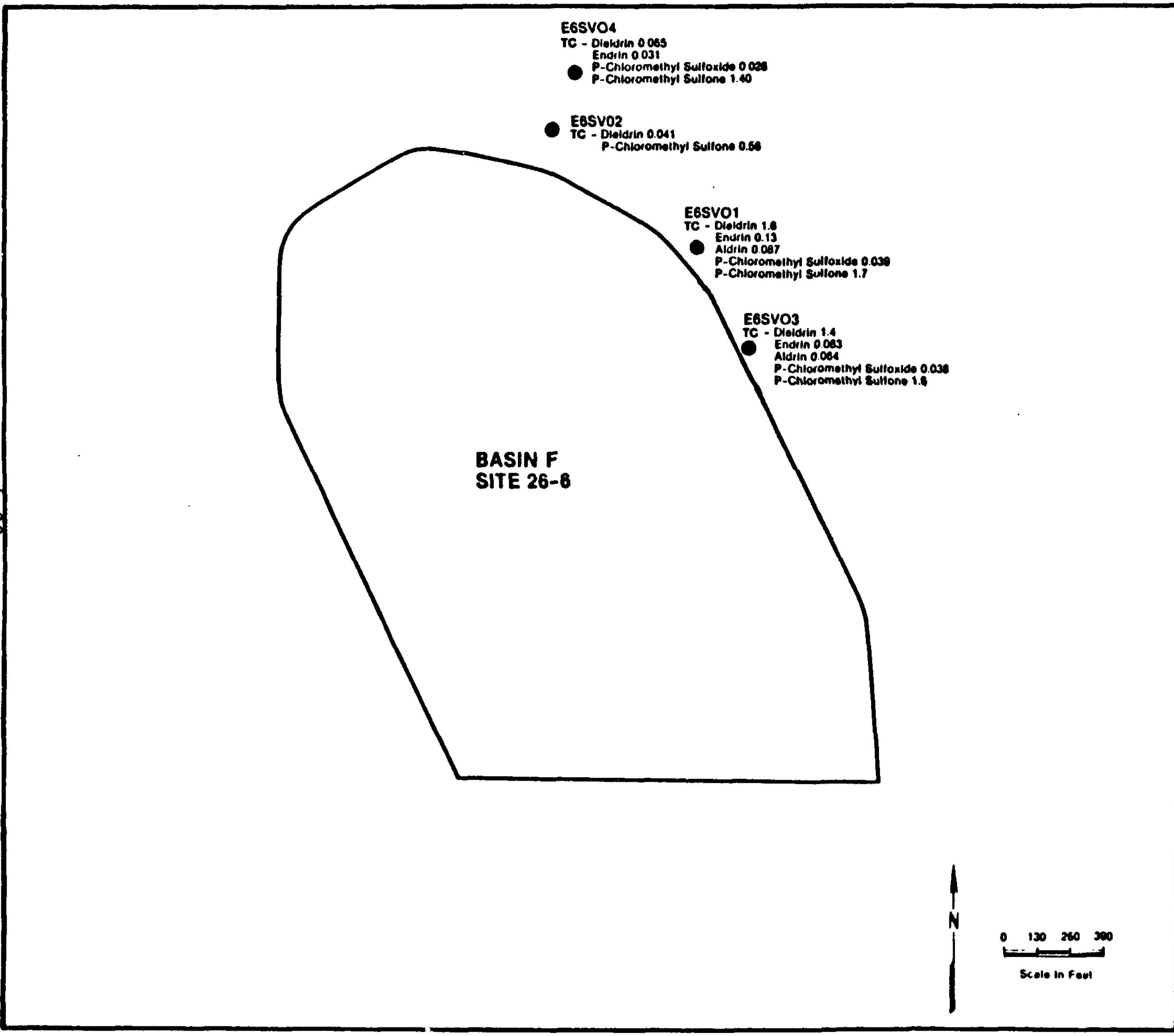
3-phenyl-2-propenoic acid ethyl ester
1,2,3,4,7,7-hexachlorobicyclo [2,2,1] hepta-2,5-diene
Dodecanoic acid
4-(2,2,3,3-tetramethylbutyl) phenol
1,2,3,4,5,7,7-heptachlorobicyclo [2,2,1] hept-2-ene
Methyltetradecanoate
Tetrachlorobenzene
6,10,14-trimethyl 2-pentadecanone
Methylhexadecanoate
1,2,3,4,10,10-hexachlora-4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene
2,6,10,15-tetramethylheptadecane

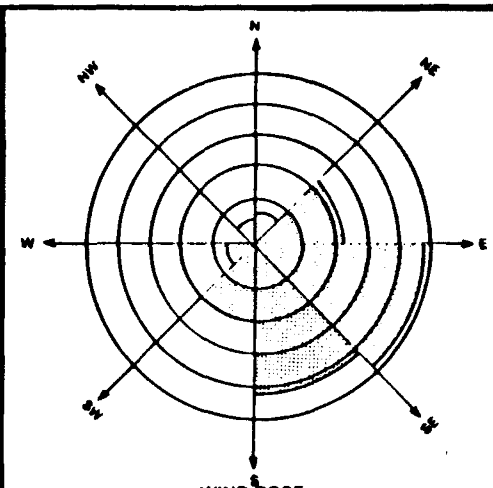
E4SVO*4

3-Phenyl 2-propenoic acid, ethylester
4-(2,2,3,3-tetramethylbutyl) phenol
1,2,3,4,5,7,7-heptachlorobicyclo [2,2,1] hept-2-ene
6,10,14-trimethyl 2-pentadecanone
2,6,10,15-tetramethylheptadecane

---

Source: ESE, 1988.




MET STATION: RMA 1 WIND ROSE SCALE: 0-30%

EXPLANATION

● E6SVO3 - Sampling Location, and Event (E6) and Sample Number (SVO3)

TC - Target Compound

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event - 6/18/87

Wind Speed - 5.0 mph

Temperature - 65.8 °F

Figure 4.1-15

SVOC - EVENT 6

SOURCE: ESE, 1987

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Table 4.1-8. Event 6 - Nontarget SVOCs.

E6SVO*1

- Heptachloronorbornene
- Tetrachlorobenzene
- Trimethylpentadecanone
- Tetramethyl heptadecane, $C_{21}H_{44}$
- Isodrin isomer

E6SVO*2

- t-butylphenol
- Trimethylpentadecanone
- Tetramethylheptadecane, $C_{21}H_{44}$
- Aliphatic hydrocarbon

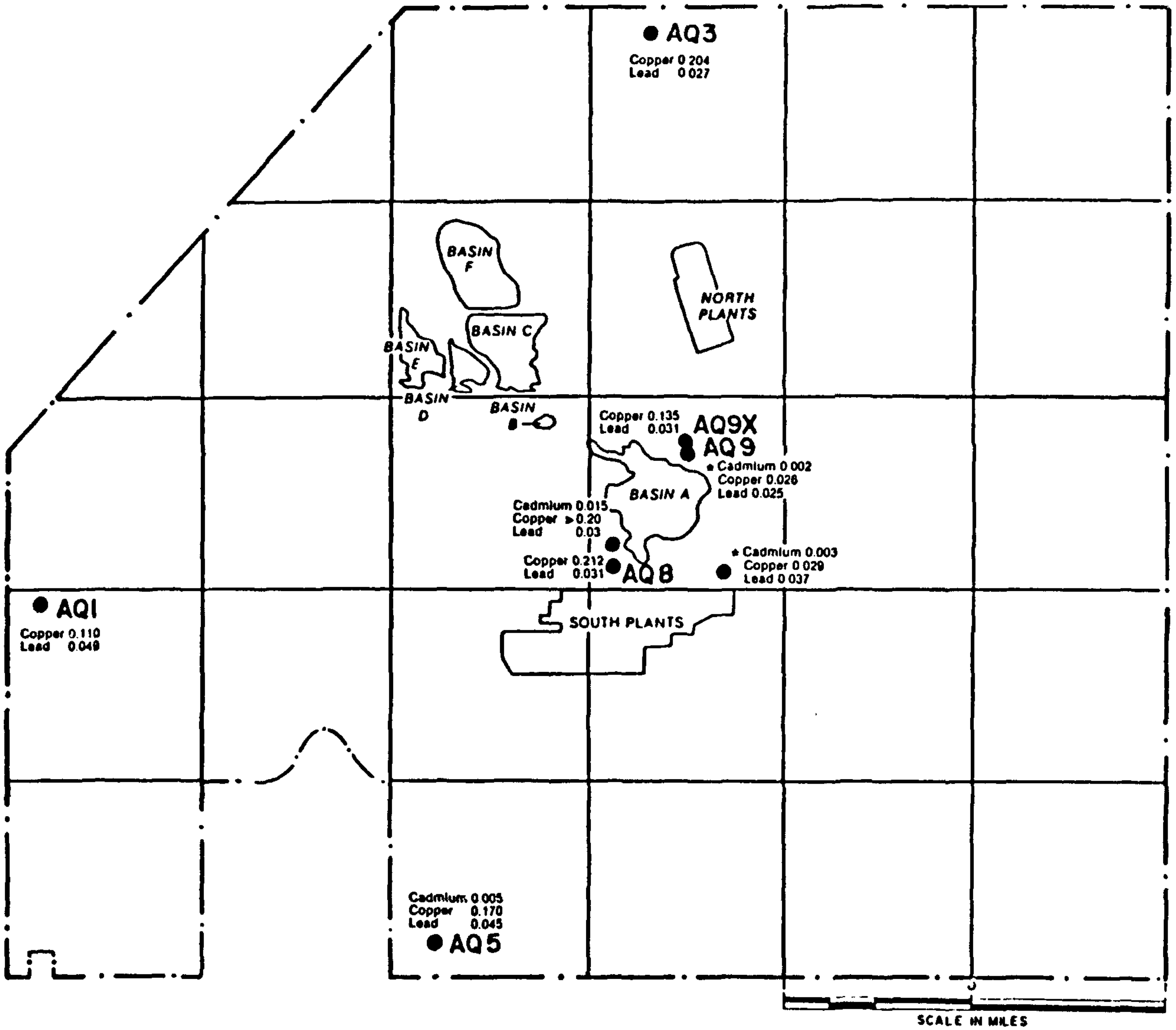
E6SVO*3

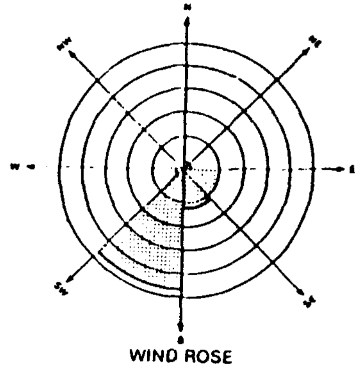
- Nonanoic acid
- Dodecanoic acid
- $CPMSO_2$ isomer
- Heptachloronorbornene
- Methyltetradecanoate
- Tetrachlorobenzene
- Trimethylpentadecanone
- Methylhexadecanoate
- Isodrin isomer
- Aliphatic hydrocarbon

E6SVO*4

- Nonanoic acid
- $CPMSO_2$ isomer
- Tetramethylbutylphenol
- Heptachloronorbornene
- Trimethylpentadecanone
- Aliphatic hydrocarbon

Source: ESE, 1988.




MET STATION: RMA 1 SCALE: 0-60%

EXPLANATION

- ● Air Quality Monitoring Station (Collected On TSP Filter)
- ★ PM-10 Sample

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 4/17/87

Wind Speed - 4.3 mph

Temperature - 64.4°F

Figure 4.1-16

METALS - EVENT 1

SOURCE: ESE, 1987

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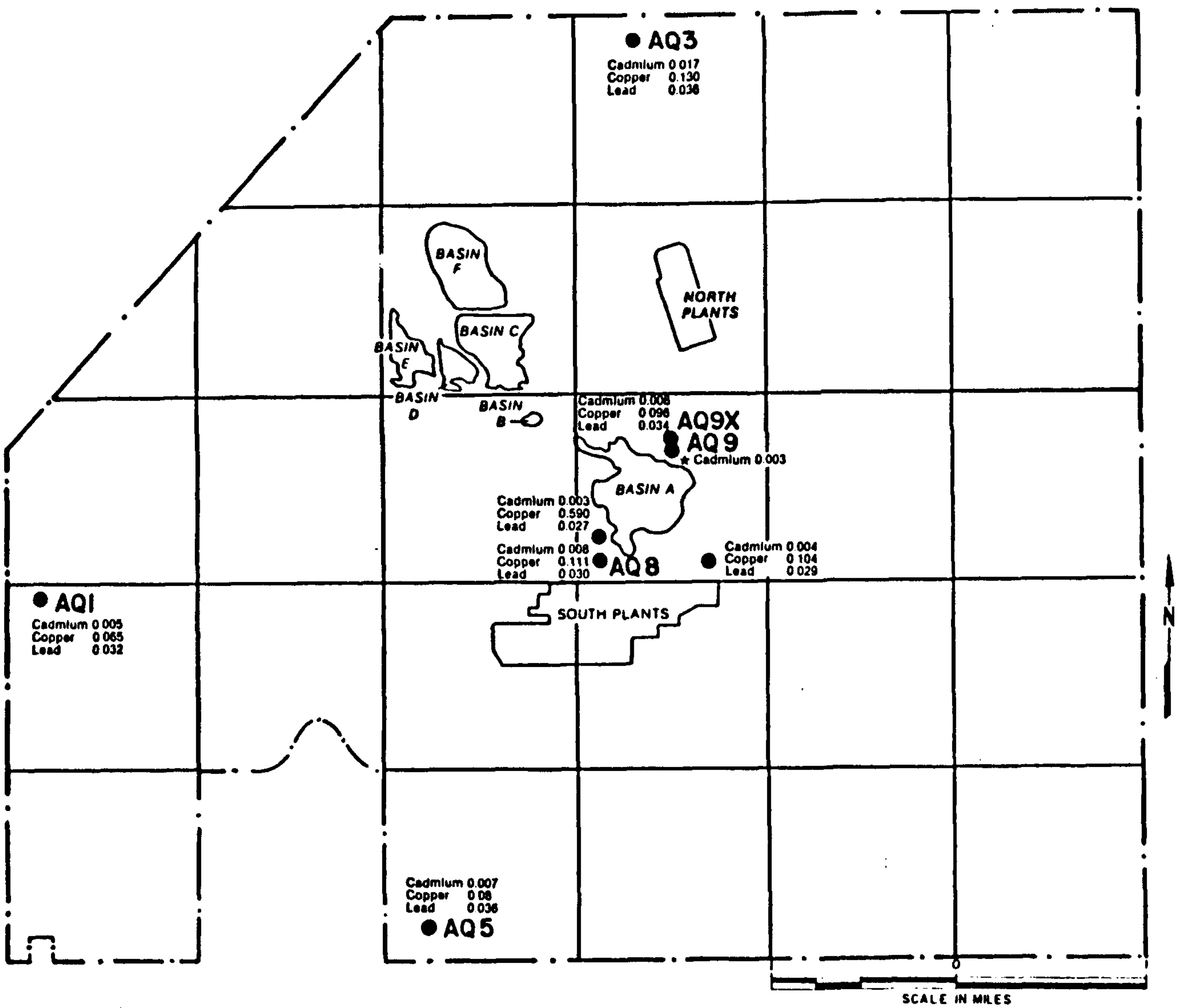


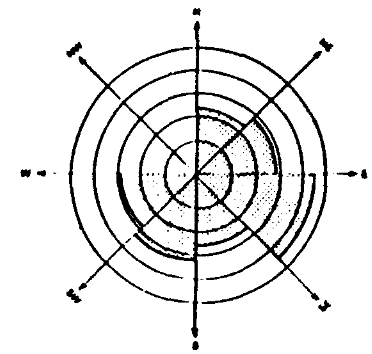


MET STATION: RMA 1 SCALE: 0-25%

EXPLANATION

- ● Air Quality Monitoring Station (Collected On TSP Filter)
- ★ PM-10 Sample

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 5/11/87

Wind Speed - 4.5 mph

Temperature - 62.5°F

Figure 4.1-17

METALS - EVENT 2

SOURCE: ESE, 1987

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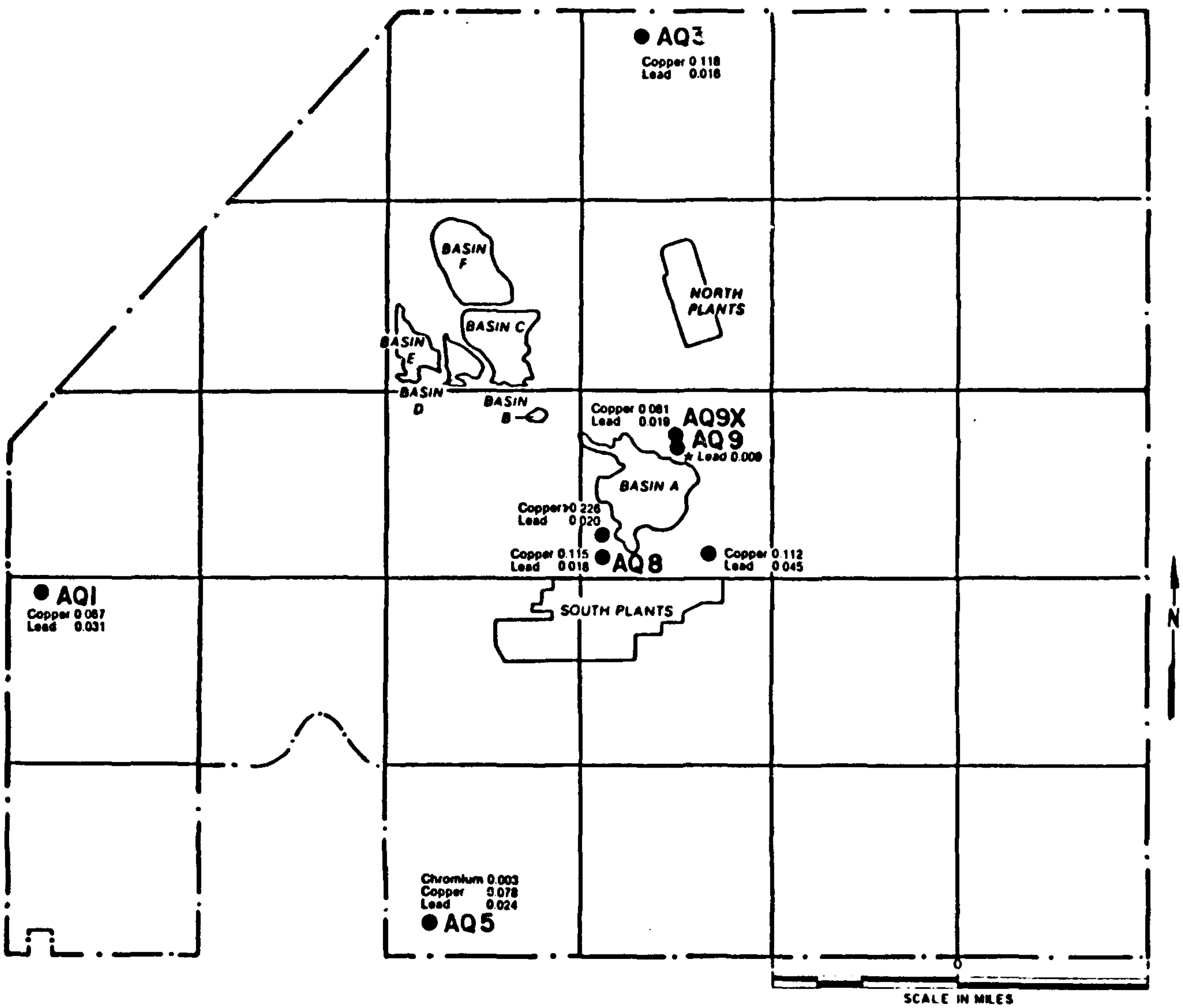


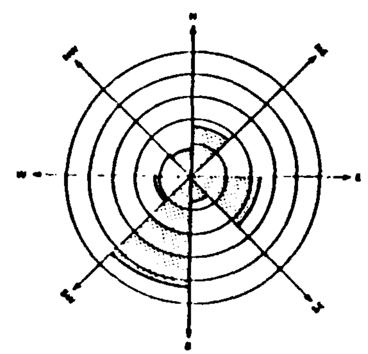


MET STATION: RMA 1 SCALE: 0 - 40%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

★ PM-10 Sample

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 5/13/87

Wind Speed - 4.0 mph

Temperature - 73.8°F

Figure 4.1-18

METALS - EVENT 3

SOURCE: ESE, 1987

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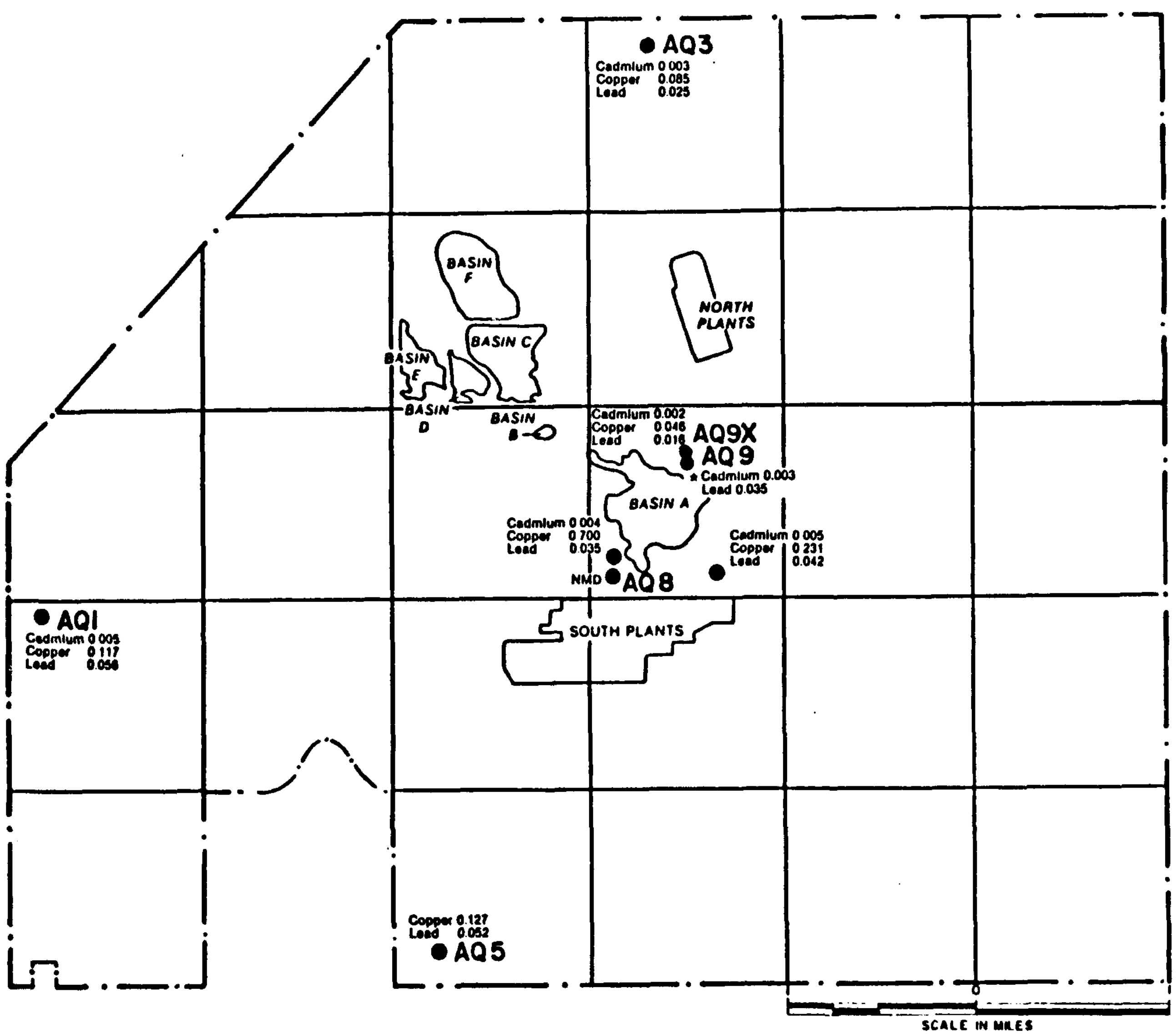


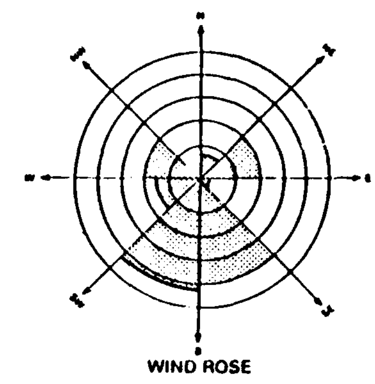


MET STATION: RMA 1 SCALE: 0-30%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

NMD - No Metals Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 5/19/87

Wind Speed - 3.4 mph

Temperature - 57.8°F

Figure 4.1-19

METALS - EVENT 4

SOURCE: ESE, 1987

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For Rocky Mountain Arsenal

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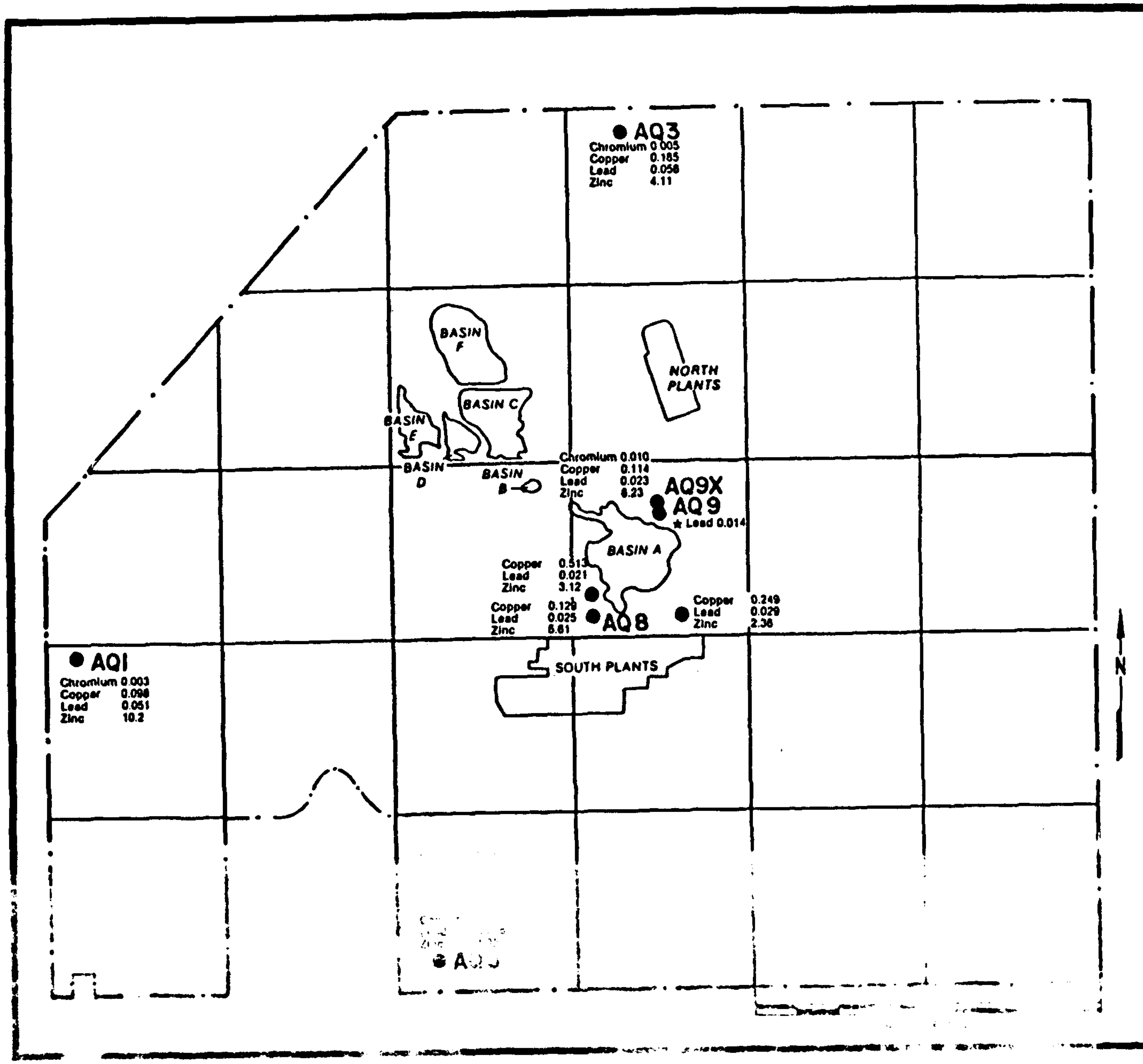


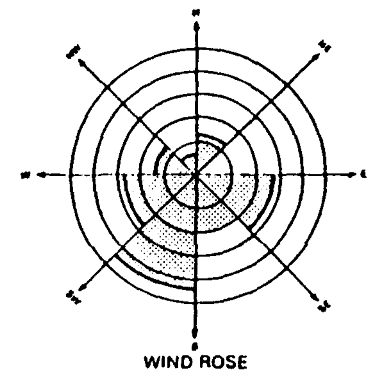


MET STATION: RMA 1 SCALE: 0-30%

EXPLANATION

- ● Air Quality Monitoring Station (Collected On TSP Filter)
- ★ PM-10 Sample

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 8/5/87

Wind Speed - 3.8 mph

Temperature - 75.1°F

Figure 4.1-20

SOURCE: ESE, 1987

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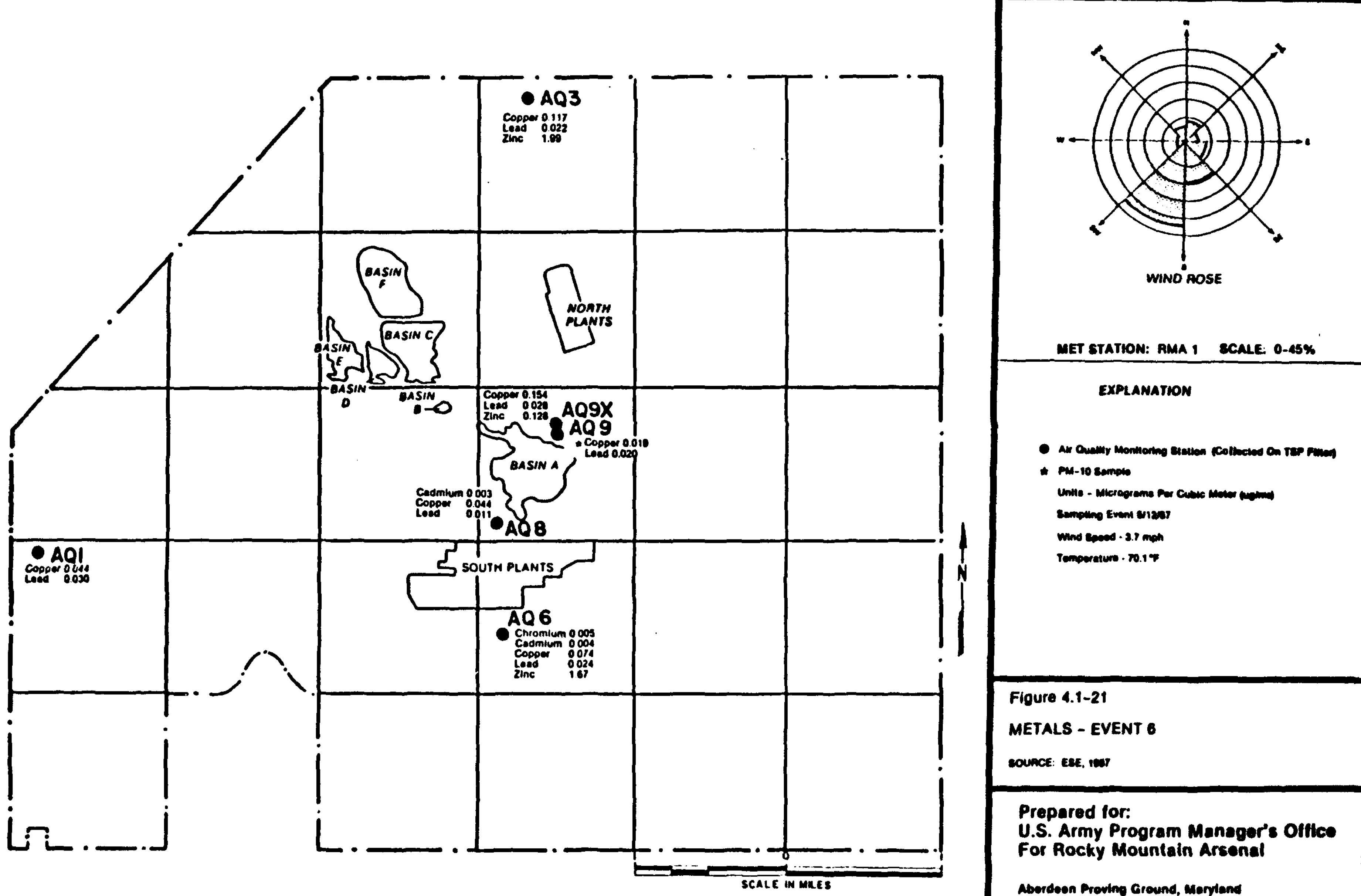


MET STATION: RMA 1 SCALE: 0-45%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

★ PM-10 Sample

Units - Micrograms Per Cubic Meter (ug/m³)

Sampling Event 8/13/87

Wind Speed - 3.7 mph

Temperature - 70.1°F

Figure 4.1-21

METALS - EVENT 6

SOURCE: ESE, 1987

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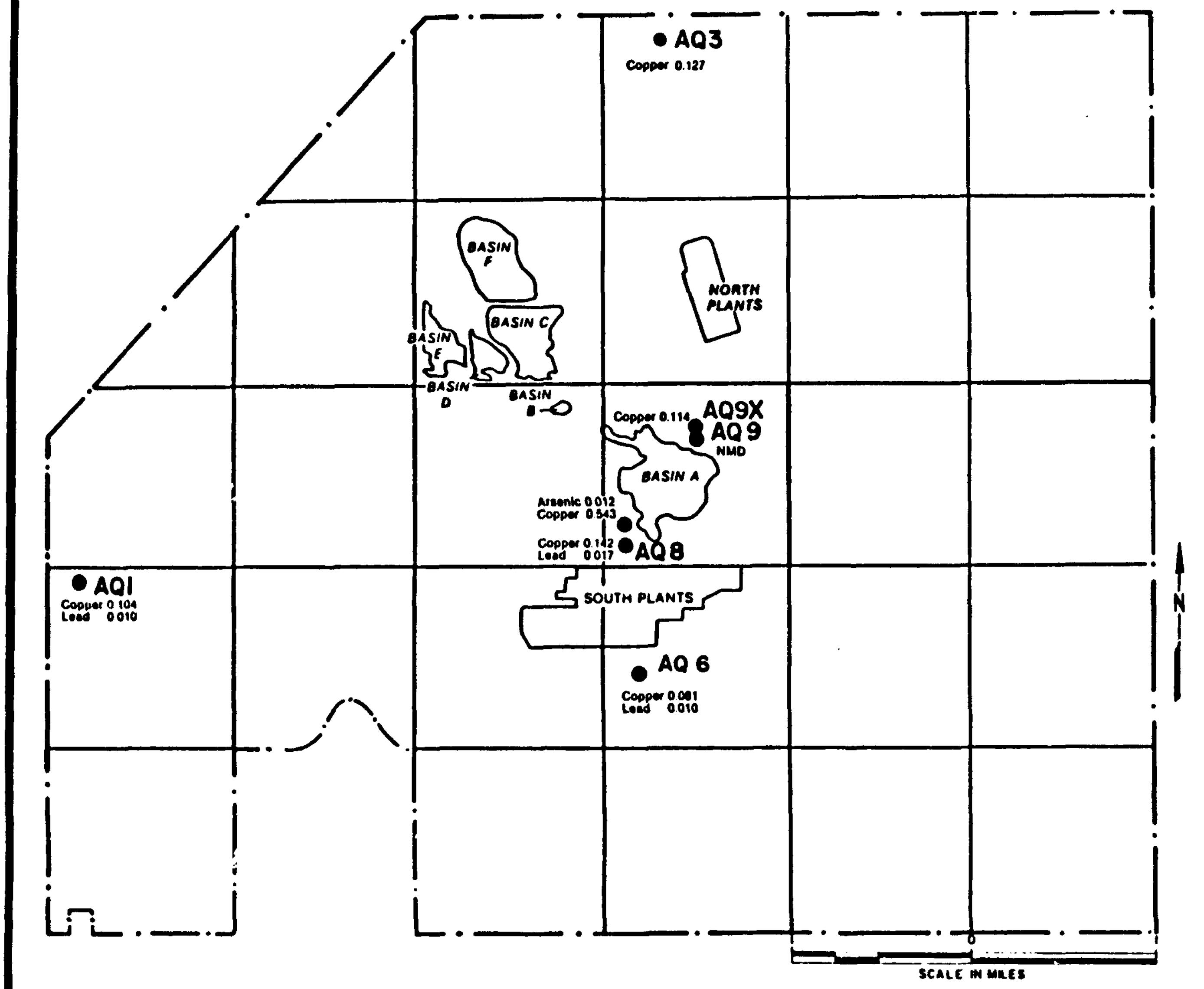
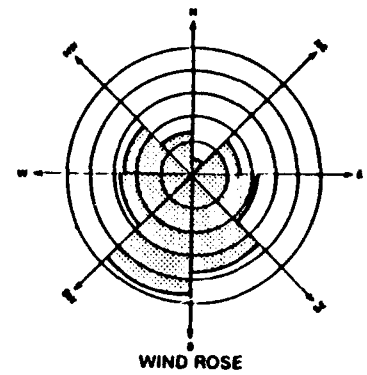
Aberdeen Proving Ground, Maryland

T18D-AR-027




MET STATION: RMA 1    SCALE: 0-25%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

NMD - No Metals Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 6/14/87

Wind Speed - 4.3 mph

Temperature - 73.2°F

Figure 4.1-22

METALS - EVENT 7

SOURCE: ESE, 1987

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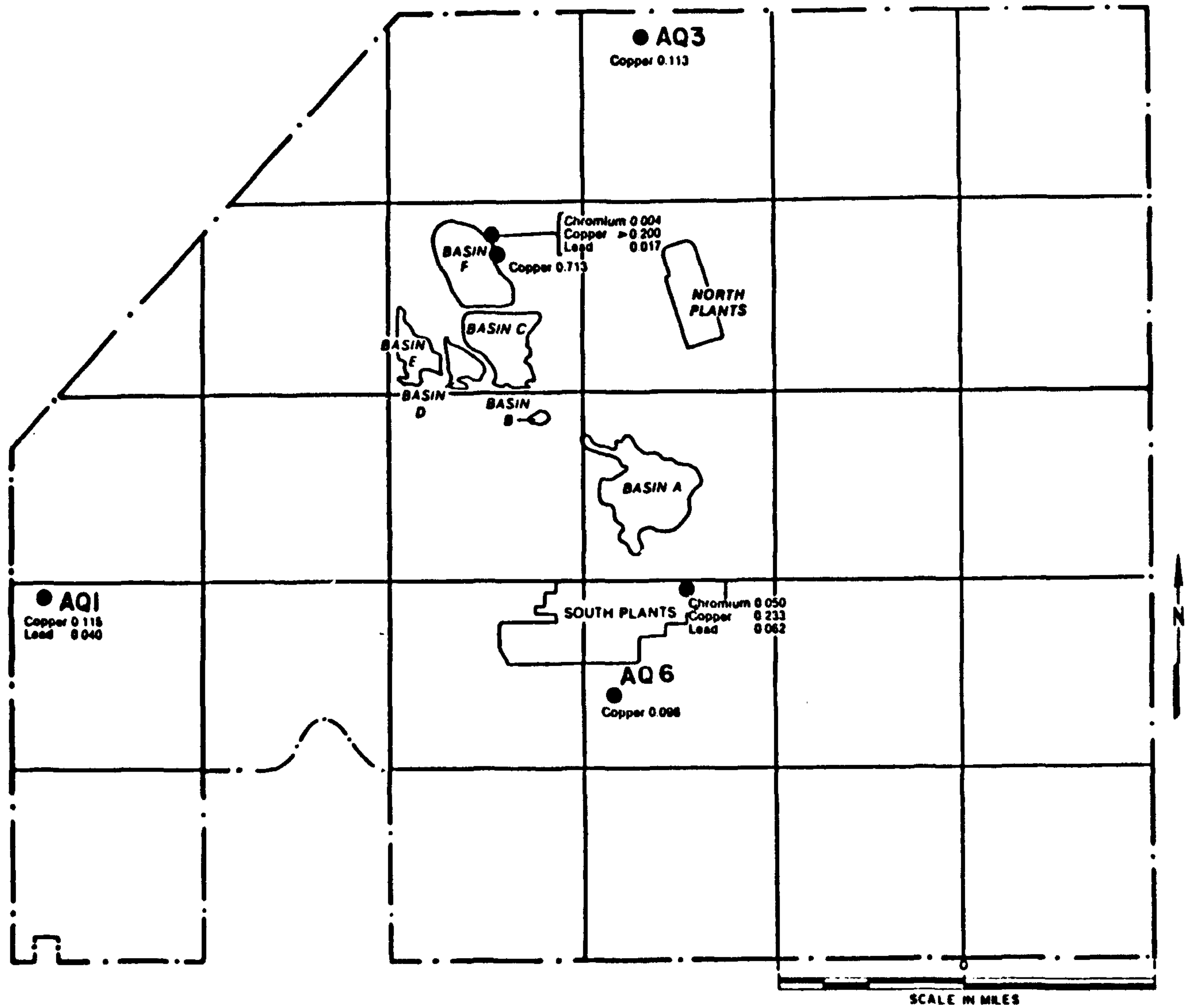
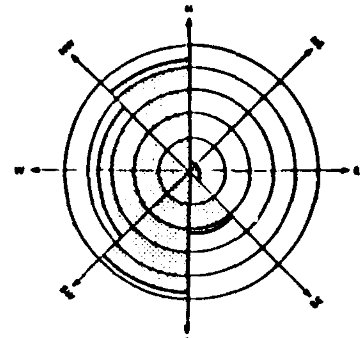
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-028




WIND ROSE

MET STATION: RMA 1 SCALE: 0-25%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 8/16/87

Wind Speed - 3.8 mph

Temperature - 74.8°F

Figure 4.1-23

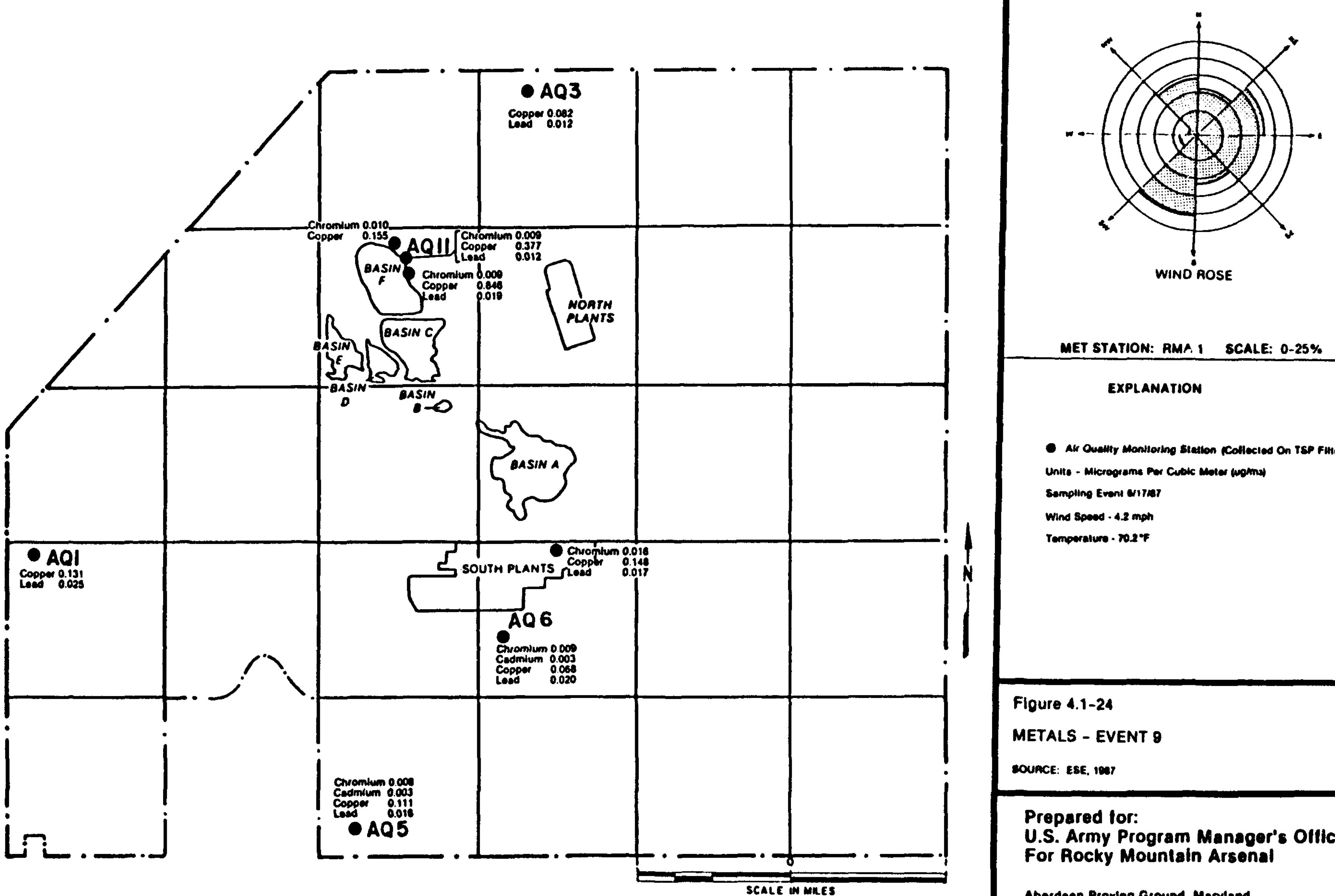
METALS - EVENT 8

SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal

Aberdeen Proving Ground, Maryland

T18D-AR-889




MET STATION: RMA 1 SCALE: 0-25%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/ms)

Sampling Event 8/17/87

Wind Speed - 4.2 mph

Temperature - 70.2°F

Figure 4.1-24

METALS - EVENT 9

SOURCE: ESE, 1987

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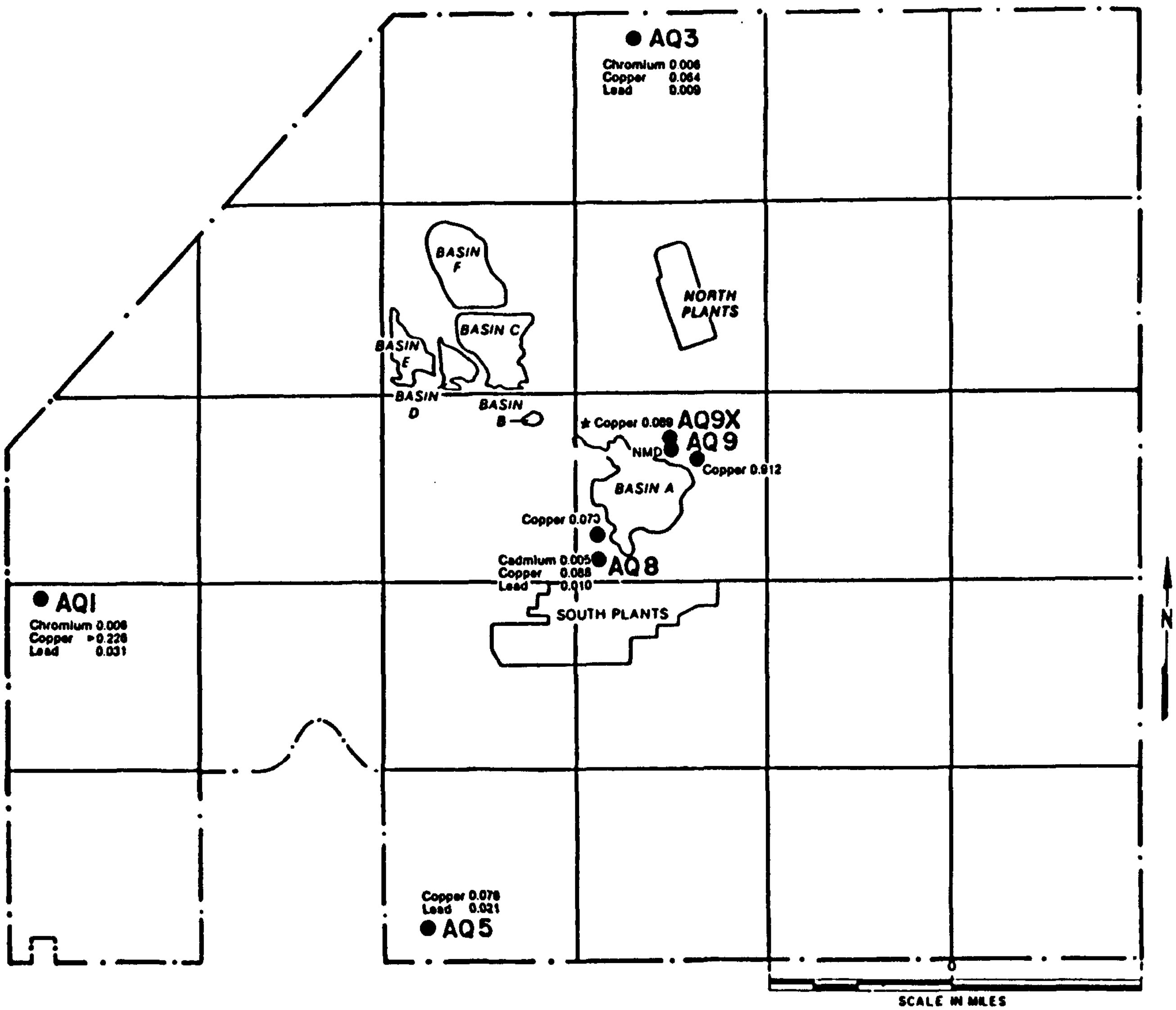
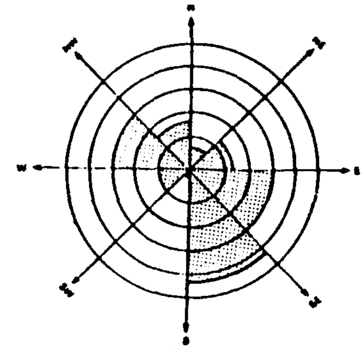
Aberdeen Proving Ground, Maryland

T18D-AR-030




MET STATION: RMA 1 SCALE: 0-30%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

NMD No Metals Detected

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 6/25/87

Wind Speed - 3.4 mph

Temperature - 85.0°F

Figure 4.1-25

METALS - EVENT 10

SOURCE: ESE, 1987

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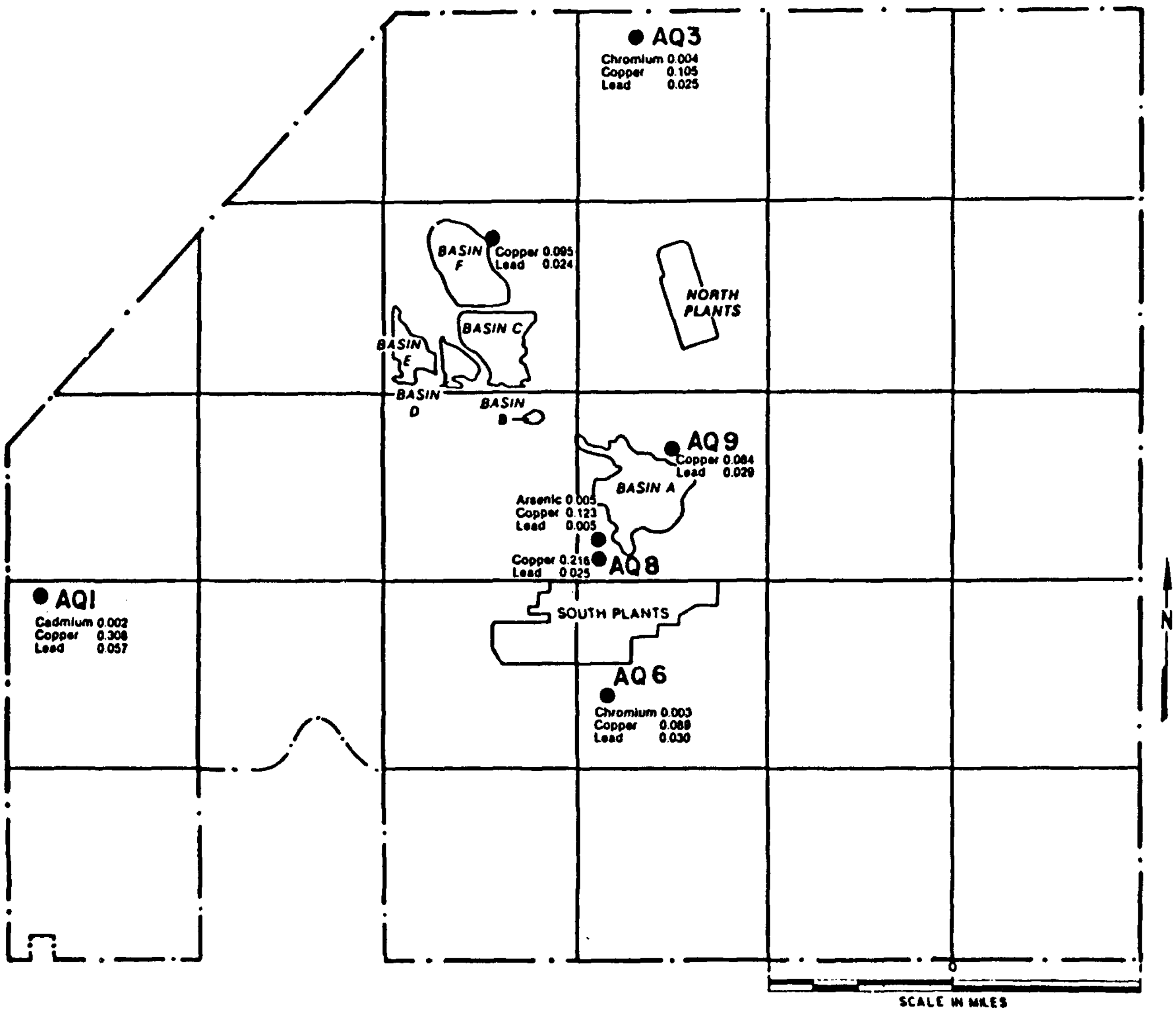
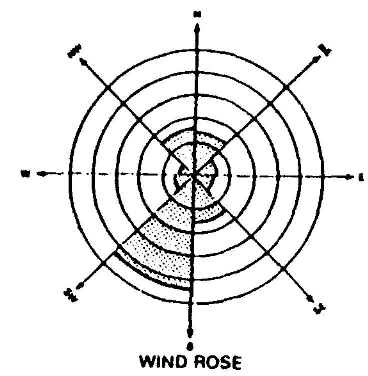
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-831




MET STATION: RMA 1 SCALE: 0-40%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 7/9/87

Wind Speed - 3.42 mph

Temperature - 75.9°F
(RMA 2)

Figure 4.1-26

METALS - EVENT 11

SOURCE: ESE, 1987

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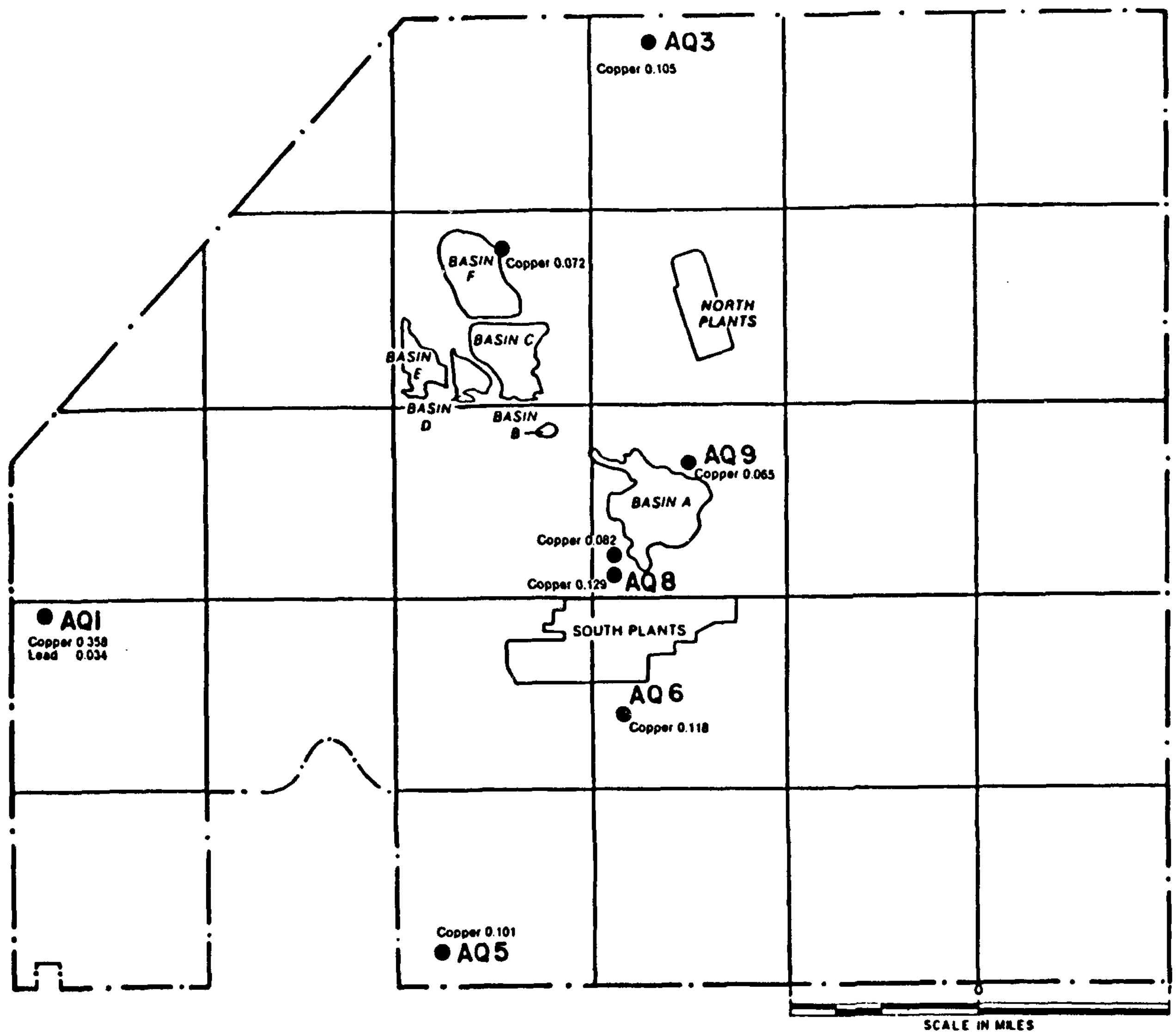
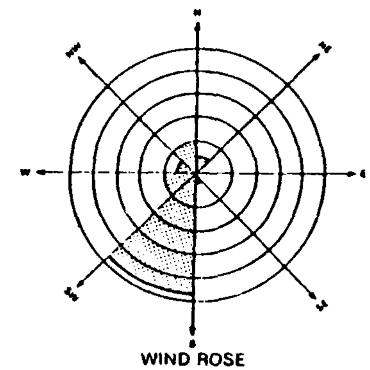
For Rocky Mountain Arsenal

Aberdeen Proving Ground, Maryland

T18D-AR-032




MET STATION: RMA 1 SCALE: 0-55%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 7/16/87

Wind Speed - 4.0 mph

Temperature - 78.8°F

Figure 4.1-27

METALS - EVENT 12

SOURCE: ESE, 1987

Prepared for:
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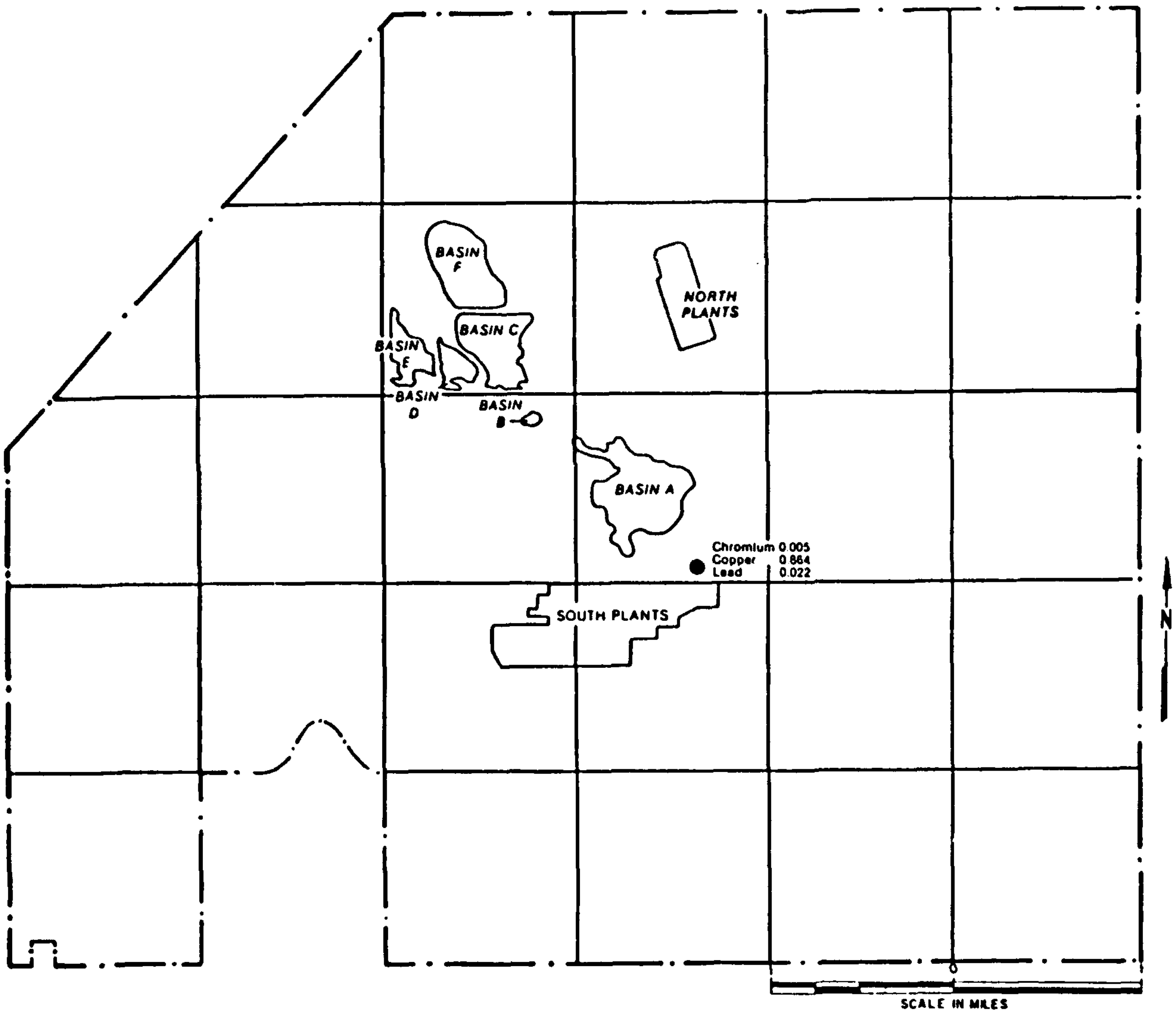
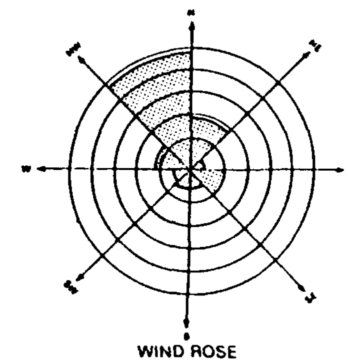
Aberdeen Proving Ground, Maryland

T18D-AR-033




MET STATION: ESE 1 SCALE: 0-40%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 8/24/87

Wind Speed - 2.1 mph

Temperature - 59.2°F

Figure 4.1-28

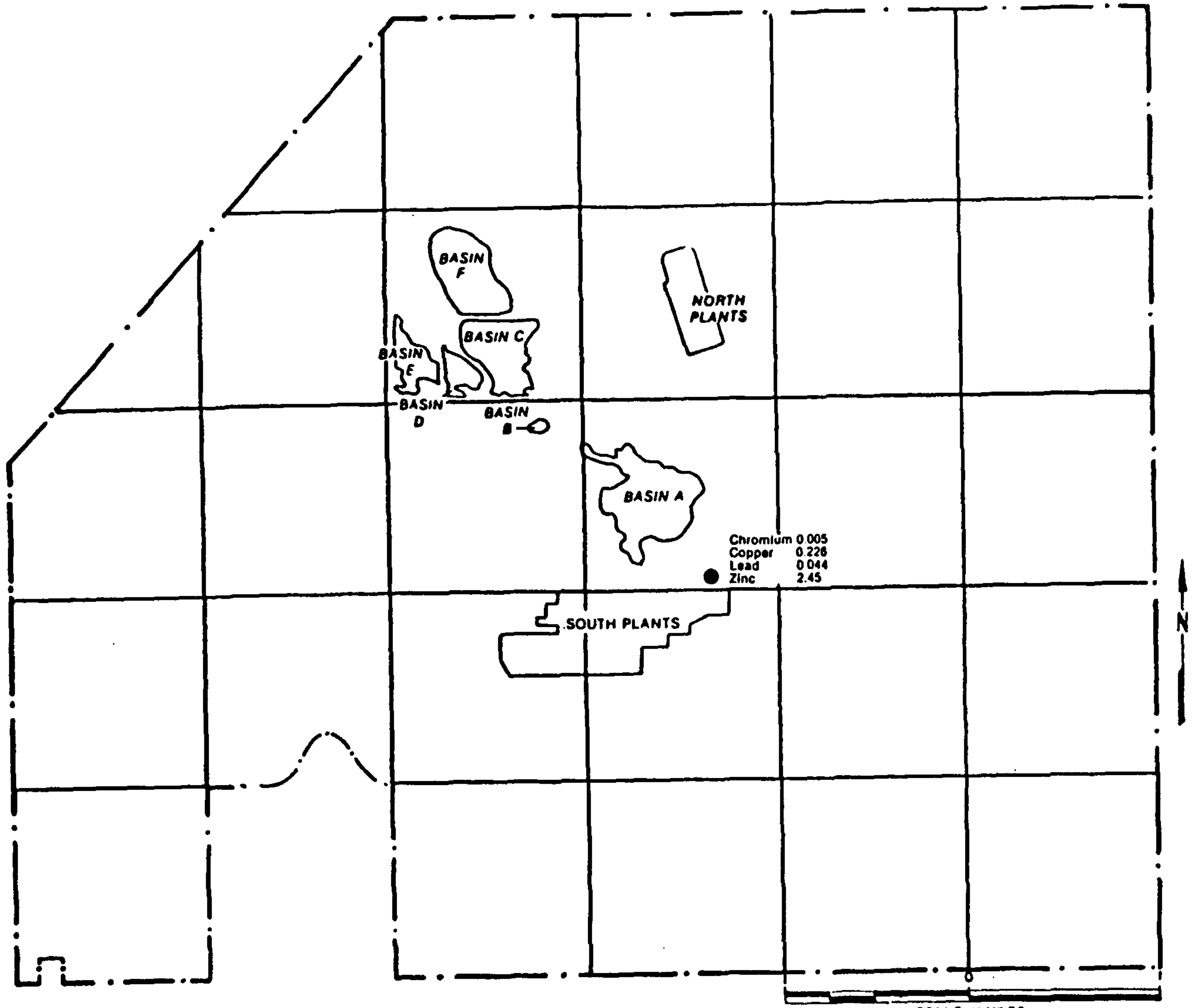
METALS - EVENT 13.1

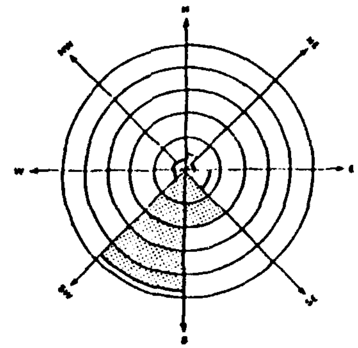
SOURCE: ESE, 1987

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T1SD-AR-034




MET STATION: ESE 1 SCALE: 0-50%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 9/1/87

Wind Speed - 3.0 mph

Temperature - 68.4°F

Figure 4.1-29

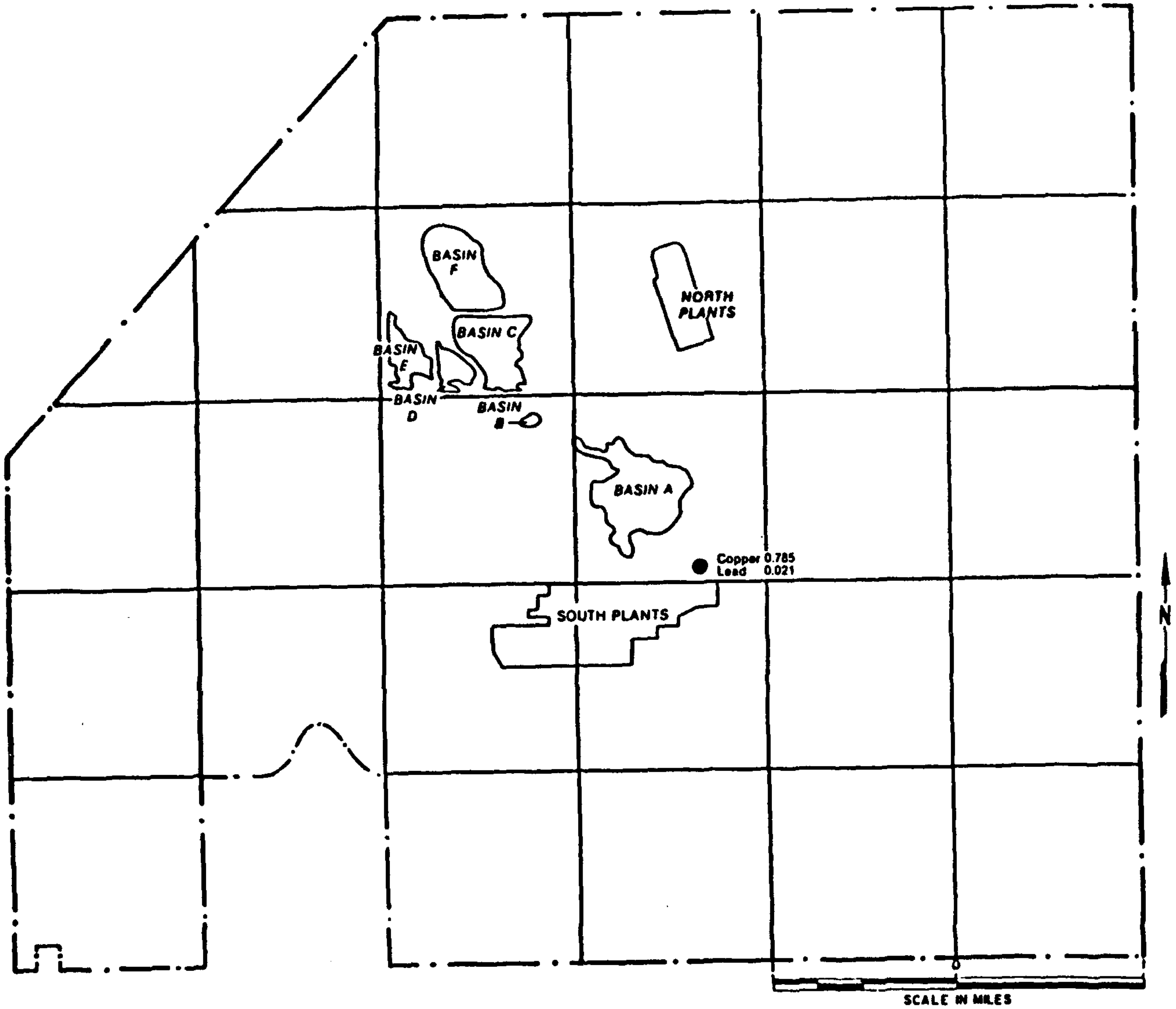
METALS - EVENT 13.2

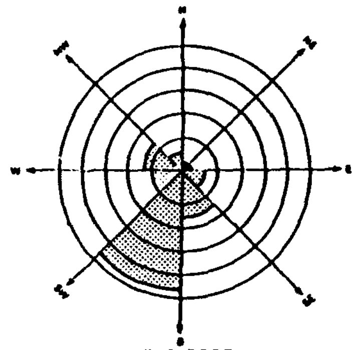
SOURCE: ESE, 1987

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-035




MET STATION: RMA 1 SCALE: 0-45%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/ms)

Sampling Event 9/3/87

Wind Speed - 3.9 mph

Temperature - 71.5°F

Figure 4.1-30

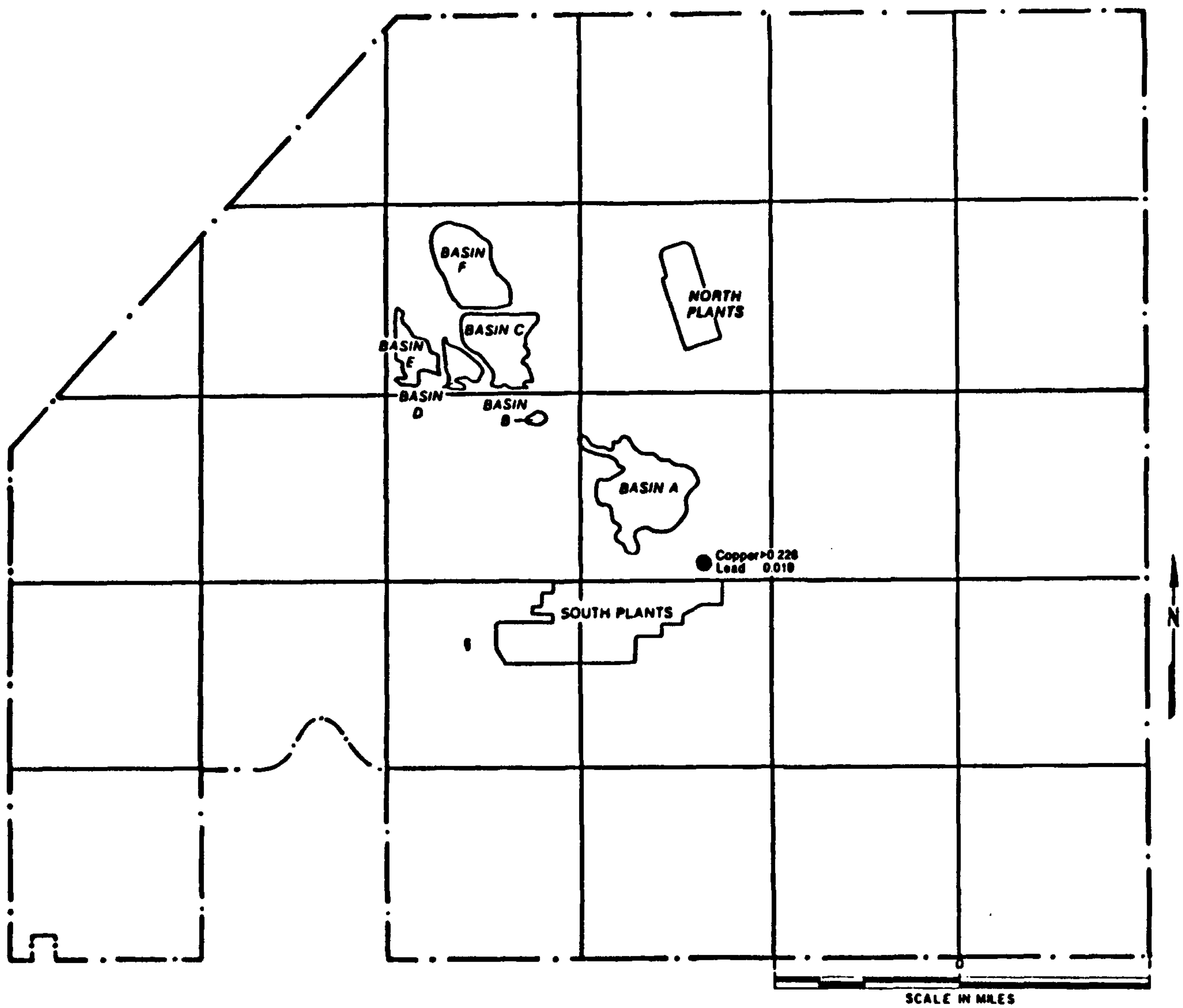
METALS - EVENT 13.3

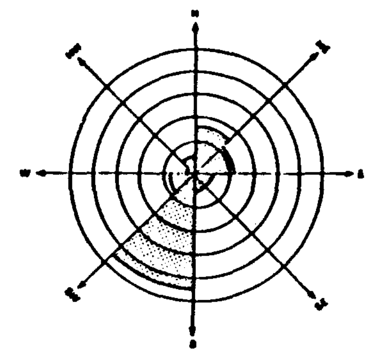
SOURCE: ESE, 1987

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-038




MET STATION: ESE 1    SCALE: 0-45%

EXPLANATION

● Air Quality Monitoring Station (Collected On TSP Filter)

Units - Micrograms Per Cubic Meter (ug/m3)

Sampling Event 9/9/87

Wind Speed - 6.5 mph

Temperature - 64.0°F

Figure 4.1-31

METALS - EVENT 13.4

SOURCE: ESE, 1987

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**

Aberdeen Proving Ground, Maryland

T18D-AR-037

Table 4.1-9. Metals Data Summary.

| Metals | Detection Limit (ug/m$^3$) | Range of Values Above Detection Limits (ug/m$^3$) From TSP Filters* | From PM-10 Filters+ |
|---|---|---|---|
| As | 0.003 | 0.005-0.012 (2)** | NHADL++ |
| Cd | 0.002 | 0.002-0.017 (21) | 0.002-0.003 (4) |
| Cr | 0.003 | 0.003-0.050 (19) | NHADL |
| Cu | 0.016 | 0.026-0.912 (81) | 0.019-0.029 (3) |
| Hg*** | 0.063 | NHADL | NHADL |
| Pb | 0.008 | 0.010-0.062 (66) | 0.009-0.037 (6) |
| Zn | 0.010 | 0.128-10.2 (11) | NHADL |

* Total number of TSP filters analyzed - 87.
\+ Total number of PM-10 filters analyzed - 7.
** Number of hits above detection limits.
++ NHADL - No hits above detection limits.
*** Hg collected on Hopcalite™ media.

The most prevalent airborne metal was copper with concentrations up to 0.912 ug/$m^3$ near Basin A. Lead was found in a majority of samples with concentrations reaching 0.062 ug/$m^3$ near South Plants. The least prevalent metal was mercury which was not found above detection limits in any of the 81 samples.

The highest metals concentrations were for zinc although most of the high zinc values were realized during one sampling event. This suggests that there possibly may have been an influence of zinc during sampling or analyses that is not representative of the airborne concentrations. Zinc is a common artifact in air samples.

The metals concentrations on TSP filters were generally higher than the concentrations on PM-10 filters during common sampling events. This correlates with the fact that less material is collected on PM-10 filters than TSP filters.

## 4.2 METEOROLOGICAL PARAMETERS

Three meterological monitoring stations were established at RMA in 1981 by the Army. The stations were designed to collect routine meteorological data and to send the data to the RMA computer center in the South Plants. Data retrieval was sporadic due to equipment, computer, and data management problems. In order to increase the reliability of data retrieval and storage, station M1 was retrofitted with a strip chart recorder and a computerized DAS. Therefore, in addition to the traditional data collection from M1, M2, and M3 at the RMA computer center, data from M1 was stored at the monitoring station and retrieved on a routine basis

The intent during this investigation was to collect a years worth of uninterrupted meterological data at M1. Due to delays in procurement of equipment and faulty equipment, less than 3 months of valid meteorological data were collected. Appendix D contains the M1 data. The RMA computer center has the additional data from M1, M2, and M3.

The data collected at M1 included:

- o Temperature;
- o Pressure;
- o Solar radiation;
- o Precipitation:
- o Wind speed;
- o Wind direction; and
- o Standard deviation of wind direction (sigma theta).

Data were used in standardizing sampling results and in defining wind conditions during specific sampling events. However, the short period for which data were collected is not useful in predicting long-term trends or defining historical conditions at RMA.

Until a more reliable method of collecting, storing, and managing meteorological data at RMA is established, the onsite data should only be used to define specific events. Meteorological data from nearby SIA are representative of the RMA-area and should be used in predicting future meteorological conditions. SIA data, such as shown in Tables 2.2-1 through 2.2-4, are useful in predicting temperature, pressure, precipitation and wind events at RMA. Historical stability data from the U.S. Department of Commerce are most representative of RMA for use in dispersion models. Until several years worth of reliable data are collected at RMA, SIA data should be used for planning and characterization purposes.

# 5.0 CONTAMINATION ASSESSMENT

The contamination assessment is an evaluation of the significance of the air quality contaminants at RMA as characterized by data collected during this investigation. For parameters like TSP, PM-10, asbestos, and Pb, the assessment is relatively straightforward as there are Federal standards for these contaminants. For VOCs, SVOCs, and metals, the contamination assessment is dependent upon the EA which evaluates environmental and health based impacts and risk.

The discussion here concentrates on assessing the impacts to air quality from TSP, PM-10, asbestos, and Pb. Because the assessment of impacts from VOCs, SVOCs, and metals on air quality is a function of the EA, the significance of the data collected during this investigation will not be evaluated here. However, the levels of toxic air contaminants realized during this investigation will be compared to typical urban concentrations as well as to previous monitoring results.

## 5.1 TSP ASSESSMENT

Historical TSP data in the Denver metropolitan area and near the vicinity of RMA show that these areas are not in compliance with primary NAAQS. Nonattainment of the standards has been attributed to the high density of these urban areas where sources such as automobiles, diesel trucks and buses, power plants, and wood-fueled heating devices have contributed to the problem.

The TSP data collected at all test sites on RMA were in compliance with both the primary and secondary annual NAAQS except for one 24-hour sample collected near South Plants. This sample was 151 ug/m$^3$ compared to a 24-hour secondary standard of 150 ug/m$^3$. The primary annual standard of 75 ug/m$^3$ is intended to protect public health and the more stringent secondary standard of 60 ug/m$^3$ protects public welfare from any known or anticipated adverse effects of the pollutant. At RMA, the highest annual geometric average TSP level was 47 ug/m$^3$ at the West and Northwest Boundaries, while the lowest was 28 ug/m$^3$ at the interior of the site. This is significant in respect to future remedial actions. At the interior of

the site where most emissions would be expected during remedial actions, there is the greatest available increment between background TSP levels and the NAAQS. At the prevailing downwind boundary, the background TSP levels are greatest allowing an increase of 13 ug/$m^3$ from onsite activities. Depending upon remedial actions and resulting emissions, NAAQS's may be exceeded offpost in the prevailing downwind direction of RMA. Dispersion modeling of anticipated clean-up scenarios would predict downwind concentration of TSP levels. This type of modeling will be investigated during future FS activities.

## 5.2 PM-10 ASSESSMENT

The EPA recently revised the national clean air standards for particulate matter, effective July 31, 1987, changing the focus from larger, total particles to smaller, inhalable respirable particles that are more damaging to human health. The new rules will replace current standards for TSP with a new indicator that includes only those particles that are 10 um or smaller. PM-10 particulates are generally created during a burning process and contain a large percentage of elemental and organic carbon. These small particles are major contributors to visibility problems. Studies show that PM-10 particles seem to be responsible for most of the adverse health effects from particulate inhalation. This is due to their ability to reach the lower regions of the respiratory tract and to the extended period of time that they are retained in the lungs.

The new annual primary and secondary standards limit PM-10 to 50 ug/$m^3$ and the new 24-hour standards are set at 150 ug/$m^3$. During 1986, the CDH-APCD monitored PM-10 at two sites within the vicinity of RMA. The data show that both sites would have been in violation of the new annual PM-10 standards. These sites have also exceeded the standards for TSP in recent years.

Because of the evolving PM-10 regulations which will specify sampling techniques, and the low collection efficiency of samples due to equipment problems during Task 18, additional sampling will be considered in the FS and in Interim Response Actions (IRAs) once the State formalizes its PM-10 program. Based upon the results of this sampling effort, PM-10 levels at RMA are highest at the boundaries and lowest at the interior of the site.

However, all PM-10 concentrations onpost at RMA are below the annual average PM-10 standards. Similarly to TSP, PM-10 concentrations will be evaluated by dispersion modeling for emissions from anticipated remedial actions during future FS activities.

## 5.3 ASBESTOS ASSESSMENT

Currently, there are no ambient air quality guidelines for acceptable levels of airborne asbestos. While the State of Colorado does use a level of 0.01 f/cc as a guideline for determining when a building is safe to reoccupy following an Asbestos Abatement, there is no standard or guideline for outdoor air. Under the Clean Air Act, the EPA has the responsibility of administering the National Emissions Standards for Hazardous Air Pollutants (40 CFR 61, Subpart M), which includes the regulation of asbestos emissions. The Colorado Air Quality Control Commission's Regulation No. 8 is similar to the Federal standard. The intent of these standards is to prevent "visible emission" of particulate asbestos fibers into the environment during removal, treatment, demolition, processing, and deposition of asbestos containing materials and to outline procedures for the proper handling and disposal of asbestos to minimize emissions. No concentration limits are specified in the standards.

The Occupational Safety and Health Administration (OSHA) promulgates standards for and regulates worker protection. The standard for asbestos specifies acceptable levels of airborne exposures for workers. The current standard for exposure to asbestos fibers without respiratory protection is an 8-hour time-weighted average (TWA) of 0.2 f/cc. The OSHA standard was developed to protect against asbestosis and does not address the carcinogenic potential of asbestos. It is also intended as an occupational standard and should not be used in assessing the risk to the public health.

All individual 8-hour samples collected at RMA were over one order of magnitude lower than the OSHA standard and below the reliable quantification of the PCM method. Studies have shown that typical ambient asbestos levels are in the order of 0.001 f/cc in rural areas and somewhat higher in urban areas. From the monitoring data, the airborne asbestos levels at RMA are in line with typical urban environments and are significantly below the OSHA

standard for worker protection. Airborne asbestos was not suspected to be migrating within or beyond the arsenal boundaries, nor migrating onto the arsenal from offpost sources.

## 5.4 VOC/SVOC ASSESSMENT

There are currently no Federal or State of Colorado VOC or SVOC regulatory requirements for ambient concentrations. The State is contemplating adoption of regulations for organic levels in the ambient atmosphere, however implementation is not imminent. The only regulation relating to organic emissions in Colorado is from point sources such as fuel storage facilities.

The VOC and SVOC concentrations monitored during this investigation at RMA are the highest levels to be expected under current conditions. However, disturbance during remedial actions may increase or decrease airborne concentrations. For example, removal of Basin F liquids will most likely increase VOC and SVOC levels. The IRA in Basin A that involves dust control will reduce airborne emissions of SVOCs.

Excluding suspected laboratory contaminants, the low levels of VOCs and SVOCs that were realized during this investigation are consistent with compounds known to occur in the source areas and are consistent with previous air monitoring investigations. Additionally, many of the compounds that were detected are common urban hydrocarbons associated with storage and combustion of petroleum fuels. Other compounds that were detected include common environmental contaminants originating from vegetation.

The levels of the VOC and SVOC that were encountered at RMA appear to be similar to levels found during historical monitoring and do not appear to be significant relative to historical monitoring. Significance as related to health risk or environmental damage is being considered as part of the EA.

## 5.5 METALS ASSESSMENT

The only guideline for ambient concentrations of metals is an NAAQS for lead. The Federal and State standard is 1.5 $ug/m^3$ averaged over 3 months. None of the metals samples collected as part of this study exceed this

standard. In most cases the lead values were less than 0.1 ug/m$^3$ and more consistent with typical urban values.

As for the other metals, mercury vapor was below detectable levels in all of the samples. Arsenic, cadmium, chromium, copper, and zinc were detected at RMA. Arsenic, cadmium, chromium, and copper were consistent with urban metals concentrations, with cadmium and copper being realized in slightly elevated levels near the basins. Zinc levels were generally consistent with urban environmental levels except for one day when concentrations were in excess of 10 ug/m$^3$. The zinc values for this day may be suspect since zinc was at low levels or not detected at all during all other events.

The health risk and environmental damage assessment from airborne metals is not part of this study. The EA is currently evaluating the significance of airborne metals originating from RMA.

## 5.6 SUMMARY OF AIR QUALITY AT RMA

Air quality has been monitored at RMA since 1969. The Army is continuing the surveillance of air quality through this task as well as through ongoing programs. Previous air monitoring programs, including Task 18, are summarizes in the following section. Additionally, the current and future air monitoring efforts under the Continuous Monitoring Program (CMP) and IRAs are discussed.

### 5.5.1 PREVIOUS INVESTIGATIONS

Numerous air quality studies have been conducted by the Army as well as other Federal and State agencies, and personnel. Historically, airborne contaminants at RMA have been associated with specific facility operations which have since ceased and no longer emit pollutants to the atmosphere.

Criteria pollutants at RMA appear to originate from sources both onpost and offpost. Because TSP and PM-10 concentrations are generally greater at the boundaries of RMA and less at the interior of the site, offpost sources such as vehicular traffic near RMA appears to be a significant source of particulates on RMA. Dried basins and other open areas at RMA that are susceptible to wind erosion are a suspected source of airborne particulates

on RMA. Current TSP and PM-10 levels are well within Federal and State guidelines.

Since facility operations have ceased and no longer emit combustion-related pollutants such as nitrogen oxides, CO, sulfur dioxide, and ozone into the air, RMA operations are not a suspected source of these pollutants. Although no recent data on these pollutant have been collected on or immediately near RMA, the combustion-related pollutants most likely originate from offpost sources such as vehicular traffic. For the combustion-related criteria pollutants, there are no current onsite data. However, for the Denver-metro area, the standards are routinely exceeded for CO and ozone. Nitrogen and sulfur dioxide standards have not been violated in the recent past in the Denver-metro area.

The sources of toxic airborne contamination at RMA appear to be from known fugitive sources emitting dust and vapors, such as basins and surface impoundments. In general, Basin F appears to be emitting the majority of VOCs and SVOCs at RMA, and Basin A is a source for airborne metals contamination. The types and concentration of contaminants found in this investigation are consistent with the results of past investigations. The significance of these findings will be determined in the ongoing EA.

### 5.6.2 CURRENT AND FUTURE INVESTIGATIONS

During the CMP and IRAs, air quality parameters are being evaluated. The CMP includes a program similar to the one described in this report. Both event and routine sampling are being conducted. The event sampling is for VOCs, SVOCs, and metals. The routine sampling is for TSP, PM-10, CO, and nitrogen oxides. Ozone and sulfur dioxide are being considered as additional parameters to be monitored in the future.

The IRAs also involve air monitoring for evaluation of airborne emissions resulting from remedial actions. These programs are specific to the location of the IRA and to the contaminant source.

If, during either the CMP or IRA sampling and analyses programs, the data indicates conditions different from those characterized during the Air RI

study, the Air RI will be re-opened for further evaluations. Specifically, if additional compounds of significance are identified or if elevated concentrations are realized, additional studies may be conducted and incorporated into this Air RI report.

## 6.0 LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACM | asbestos containing material |
| AQ | Air Quality Station |
| CDH-APCD | Colorado Department of Health - Air Pollution Control Division |
| CFI | Colorado Fuel and Iron Corporation |
| DAS | data acquisition system |
| EPA | U.S. Environmental Protection Agency |
| $^{o}F$ | degrees Fahrenheit |
| f/cc | fibers per cubic centimeter |
| ft | feet |
| GB | Sarin nerve agent |
| GC/MS | gas chromatography/mass spectrometry |
| Hyman | Julius Hyman and Company |
| mph | miles per hour |
| um | micron or micrometer |
| ug/l | micrograms/liter |
| $ug/m^3$ | micrograms per cubic meter |
| MOA | Memorandum of Agreement |
| MRI | Midwest Research Institute |
| NAAQS | National Ambient Air Quality Standards |
| NBCS | North Boundary Containment System |
| NCC | National Climatic Center |
| NIOSH | National Institute of Occupational Safety and Health |
| OSHA | Occupational Safety and Health Administration |
| PCM | phase contrast microscopy |
| PID | Photoionization Detector |

| | |
|---|---|
| PMO | Program Manager's Office |
| PM-10 | particulate matter less than 10 microns |
| ppm | parts per million |
| QA | Quality Assurance |
| QC | Quality Control |
| RCI | Resource Consultants, Inc. |
| RIC | Rocky Mountain Arsenal Resource Information Center |
| RI/FS | Remedial Investigation/Feasibility Study |
| RMA | Rocky Mountain Arsenal |
| Shell | Shell Chemical Company |
| SIA | Stapleton International Airport |
| Spaine | Spaine *et al.*, 1984 |
| SVOC | semivolatile organic compound |
| TCDHD | Tri-County District Health Department |
| TEM | transmission electron microscopy |
| TSP | total suspended particulates |
| TWA | time-weighted average |
| USAEHA | U.S. Army Environmental Hygiene Agency |
| USAMBRDL | U.S. Army Medical and Bioengineering Research and Development Laboratory |
| USATHAMA | U.S. Army Toxic and Hazardous Materials Agency |
| USDHEW | U.S. Department of Health, Education, and Welfare |
| VOC | volatile organic compound |
| WES | U.S. Army Waterways Experiment Station |
| WWII | World War II |

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